California Regional Water Quality Control Board
Central Valley Region
Katherine Hart, Chair

Linda S. Adams
Secretary for Environmental Protection

11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

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To: Interested Parties

SUPPLEMENTAL INFORMATION ON SOURCE ANALYSIS FOR THE 19 AUGUST STAKEHOLDER MEETING FOR A PROPOSED BASIN PLAN AMENDMENT TO ADDRESS ORGANOCHLORINE PESTICIDES IN SEVERAL CENTRAL VALLEY WATERBODIES

On 19 August, Central Valley Water Board staff will hold a public meeting to discuss the development of a proposed Basin Plan Amendment (BPA) to address organochlorine (OC) pesticides in several Central Valley waterbodies. Attachment 1 to this letter provides supplemental information regarding source analysis of OCs. The supplemental information provides more information on the proposed approach for source analysis including an assessment of current conditions for OC constituents in Central Valley watersheds. This information is provided to encourage early stakeholder discussion about potential options for the OC TMDL and no policy or regulation is either expressed or intended.

Due to the large amount of supplemental material provided on source analysis, discussion of linkage analysis, potential load and waste load allocations have been moved to a separate additional meeting. The updated meeting schedule is provided below. These meetings form part of a series of stakeholder meetings in the form of modules to be held through February 2011. Preliminary draft BPA text associated with each module is provided approximately one to two weeks prior to each meeting.

Module #	Topic	Previous Tentative Dates	Proposed Revised Dates
1	Project Scope, Watershed background, Sources, Potential Targets	17 June	On-schedule
2	Source analysis	4 Aug	19 Aug
3	Linkage analysis and Allocations (Load and Waste Load Allocations)		12 Oct
4	Implementation and related (Part 1)	20 Sept	14 Dec
5	Implementation and related (Part 2)	3 Nov	18 Jan 2011
6	Synthesis of all previous Modules	18 Jan 2011	22 Feb 2011

These stakeholder meetings will be followed by the formal BPA process, for example formal comment periods on the Public Review Draft and revised Final Draft Staff Report (including draft BPA text) prior to Regional Board adoption hearing (anticipated August 2011). Staff encourages comments on additional options or any other relevant information that should be considered during the BPA process.

Staff recognizes that there is a substantial amount of information provided in this Attachment with limited time for review prior to the 19 August meeting. At the meeting, staff will give a presentation on the material provided in this Attachment. Due to the length of material provided, the informal comment period will be extended an additional week (comments due 9 September).

FRED KIZITO
Environmental Scientist
Pesticide TMDL Unit

Enclosure: Attachment 1 (Module 2 Supplemental Source Analysis)

ATTACHMENT 1: MODULE 2 SUPPLEMENTAL INFORMATION ON SOURCE ANALYSIS

This document (Attachment 1) provides supplemental information for the upcoming stakeholder meeting on 19 August 2010 at the Regional Board offices in Rancho Cordova for a proposed Basin Plan Amendment (BPA) to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins. The proposed Amendment will develop Total Maximum Daily Loads (TMDLs) for Organochlorine (OC) pesticides in several waterbodies located in the Sacramento River basin, San Joaquin River basin and Sacramento-San Joaquin Delta. As there was only a small amount (a few paragraphs) of BPA text that discusses language relevant to sources of OCs, staff opted to provide this Supplemental Attachment first (as Module 2). The preliminary BPA text relevant for sources of OCs with the draft linkage analysis and allocation BPA text will be provided as part of Module 3.

1. Introduction

Organochlorines are a group of man-made pesticides that are hard to breakdown. As a result, they persist in the environment and magnify in the food chain. OC constituents were primarily used as insecticides, fungicides and anti-microbial chemicals in residential, urban and agricultural applications for pest control until their use was banned by the US EPA over varying years depending on the OC chemical.

2. Information Related to Source Assessment

2.1 Current Conditions Assessment

This section summarizes available information and monitoring data that describes the presence of OC constituents in the impaired reaches in the Central Valley watersheds. For this preliminary information regarding source assessment, DDE and Lindane were chosen as representative constituents based on frequency of detection and concentration levels. These two chemicals possess many similar physical and chemical properties to other OC constituents that influence their fate and transport in the environment. DDE represents constituents that were consistently detected in Central Valley watersheds. The timeframe for the data analyzed in this Report spans from 1978 through 2008.

In Region 4’s TMDLs (Total Maximum Daily Load for Organochlorine Pesticides, Polychlorinated Biphenyls, and Siltation in Calleguas Creek, Its Tributaries, and Mugu Lagoon) (Calleguas Creek TMDL, 2006), DDE was classified as a Category I constituent. Other constituents in this category include DDT, DDD, Chlordane, Toxaphene and Dieldrin. On the other hand, Lindane represents constituents that are detected infrequently in the Region 4 project area and were often at low concentration levels and this was classified as a Category II constituent. Other constituents in this group include Aldrin, Endrin, Endosulfan, Heptachlor and Heptachlor epoxide, Methoxychlor and Hexachlorohexanes. For this Central Valley OC TMDL, Central Valley Water Board staff has not yet decided if a similar approach to Region 4 should be taken. In this preliminary document, a detailed discussion of current conditions is presented below for both Category I and Category II constituents using both historic and recent (1978 through 2008) water, sediment, and fish tissue data.

2.1.1 Sources of Monitoring Data

Since the late 1970's various studies have been conducted to assess water, sediment, and fish tissue quality in the Central Valley. Data collected from these studies is presented in this Attachment in order to assess current conditions in Central Valley watersheds. With regards to data used for the current 2006 303d listings, the portion of available data that formed the basis for the listings was mainly fish tissue monitored through the Toxic Substances Monitoring Program (TSMP). The TSMP primarily targeted water bodies with known or suspected water quality impairments, and successfully identified and documented many hotspots of contamination (Rasmussen 1995). Species-specific fish tissue data were available for OC constituents for the time period 1978 - 2002. This section presents additional data (water column, sediment, and tissue chemistry) that was not used for the 303(d) list but was compiled by TMDL staff as part of TMDL development. Data sources, years of data collection and associated media types for data are shown in Tables 1, 2 and 3 in Section 2.1.2 below. A quick snapshot of Tables 2 and 3 indicates that by far, the most common matrix monitored from currently available data was the water column. Conversely, very few samples of sediment data were found (Tables 2 and 3).

Table 1. Data sources complied for development of OC TMDL and Proposed BPA.

Data Source	Begin Date	End Date	Fish Tissue	Sediment	Water Column	Study/Source
G. Fred Lee & Associates	1997	2005	X			Update of Organochlorine (OCl) "Legacy" Pesticide and PCB Concentrations in Delta and the Central Valley Fish. (Lee and Jones-Lee, 2007)
Department of Pesticide Regulation	1991	2000			X	Department of Pesticide Regulation Surface Water Database (DPR, 1991-2000)
USGS (NAWQA)	1992	2005		X	X	USGS National Water Quality Assessment Data Warehouse (USGS, 1992-2005)
SRWP	2005	2007	X			Final Proposition 50 Grant Monitoring Report 2005 – 2007 (Larry Walker Associates, 2007)
USACE	2004	2009		X		United States Army Corps of Engineers. Stockton Deep Water Ship Channel. Maintenance Dredging Monitoring Program. 2004-2009. (USACE, 2004-2009)
SWAMP 1 Surface Water Ambient Monitoring Program	2005	2005	X			Organochlorine Pesticides and Polychlorinated Biphenyls (PCB) Concentrations in Muscle Tissue of Fish Collected from the San Joaquin River and Sacramento River

Table 1. Data sources complied for development of OC TMDL and Proposed BPA.

						Watersheds and Delta During 2005 (de Vlaming, 2008)
SWAMP 2 Surface Water Ambient Monitoring Program	2007	2008	X			Contaminants in Fish from California Lakes and Reservoirs (2007-2008) (SWAMP, 2007)
ILRP	2004	2009		X	X	Irrigated Lands Regulatory Program (Coalitions Monitoring Efforts 2004-2009) (Central Valley RWQCB, 2004-2009).
TSMP	1978	2000	X			Toxic Substances Monitoring Program (1978-2000) (State Water Board, 2002)
NPDES	2000	2009			X	Central Valley Water Board: Submitted Self Monitoring Reports (Central Valley RWQCB, 2000-2009).

More information on data sources listed in Tables 1 and 2 can be accessed at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/central_valley_organochlorine_pesticide/index.shtml

Table 2: OC data sources with corresponding no. of samples in each impaired reach							
Waterbody Name	**Matrix**	**Data Source, Study Dates for Number of Samples within un-shaded Impaired Reaches**					
		Lee 1997-2005	**DPR 1991-2003**	**USGS 1992-2005**	**SRWP 2005-2007**	**USACE 2004-2009**	**SWAMP Study** 2005**
San Joaquin River (Mendota pool to Bear Creek)	Water Column						
	Sediment						
	Fish	30*					3
San Joaquin River (Bear Creek to Mud Slough)	Water Column			181			
	Sediment			10			
	Fish						6
San Joaquin River (Mud Slough to Merced River)	Water Column						
	Sediment						
	Fish	14*					
San Joaquin River (Merced River to Tuolumne River)	Water Column		147	174			
	Sediment			9			
	Fish	22					33
San Joaquin River (Tuolumne River to Stanislaus River)	Water Column						
	Sediment						
	Fish	22					
San Joaquin River (Stanislaus River to Delta Boundary)	Water Column			1192			
	Sediment			14			
	Fish						27
Tuolumne River, Lower (Don Pedro Reservoir to San Joaquin River)	Water Column			474			
	Sediment			16			
	Fish						12
Stanislaus River, Lower	Water Column			344			
	Sediment			5			
	Fish						9
Orestimba Creek	Water Column			1096			
	Sediment			3			
	Fish						
Merced River, Lower (McSwain Reservoir to San Joaquin River)	Water Column			951			
	Sediment			9			
	Fish						12
Feather River, Lower (Oroville Dam to confluence with Sacramento River)	Water Column			12			
	Sediment			24			

Table 2: OC data sources with corresponding no. of samples in each impaired reach

Waterbody Name	Matrix	Data Source, Study Dates for Number of Samples within un-shaded Impaired Reaches: Lee 1997-2005	DPR 1991-2003	USGS 1992-2005	SRWP 2005-2007	USACE 2004-2009	SWAMP Study** 2005
	Fish						77
Colusa Basin Drain	Water Column						
	Sediment			24			
	Fish				21		36
Delta Waterways (SDWSC / Stockton Ship Channel)	Water Column						
	Sediment					330	
	Fish	11					
Delta Waterways (Eastern portion)	Water Column						
	Sediment						
	Fish						39
Delta Waterways (Western portion)	Water Column						
	Sediment						
	Fish						6
Delta Waterways (Southern portion)	Water Column						
	Sediment						
	Fish						12
Delta Waterways (Northern portion)	Water Column						
	Sediment						
	Fish				141		57
Delta Waterways (Central Portion)	Water Column						
	Sediment						
	Fish	26					63
Delta Waterways (Export area)	Water Column						
	Sediment						
	Fish						6
Delta Waterways (Northwestern portion)	Water Column						
	Sediment						
	Fish						30

*: Indicates that source had similar data to TSMP samples; one data source was considered
**: Some data could include portions beyond impaired reach extending into the Project Area
Blank shaded spaces indicate that no data is available

Table 3. OC data sources with corresponding no. of samples in project area watersheds

Subarea within Project Area	**Matrix**	**Data Source, Study Dates for Number of Samples in Project Area (may include portions of Impaired Reaches)**		
		ILRP 2004-2009	**TSMP 1978-2000**	**NPDES 2000-2009**
Fresno-Chowchilla	Water Column			220
	Sediment			
	Fish		30	
Bear Creek	Water Column			120
	Sediment			
	Fish		47	
Grassland	Water Column			
	Sediment	895		
	Fish		14	
Merced River	Water Column			422
	Sediment			
	Fish		33	
East Valley Floor	Water Column			573
	Sediment	349		
	Fish		51	
Tuolumne River	Water Column	138		315
	Sediment			
	Fish		272	
Stanislaus River	Water Column			541
	Sediment			
	Fish		129	
Greater Orestimba	Water Column			
	Sediment	977		
	Fish		112	
Westside Creeks	Water Column			
	Sediment	738		
	Fish		32	
Vernalis North	Water Column			
	Sediment			
	Fish		146	

Table 3. OC data sources with corresponding no. of samples in project area watersheds

Subarea within Project Area	Matrix	Data Source, Study Dates for Number of Samples in Project Area (may include portions of Impaired Reaches)		
		ILRP 2004-2009	TSMP 1978-2000	NPDES 2000-2009
Feather River, Lower (Oroville Dam to confluence with Sacramento River)	Water Column			121
	Sediment			
	Fish			568
Colusa Basin Drain	Water Column			
	Sediment	1714		
	Fish		91	
Delta Waterways (SDWSC / Stockton Ship Channel)	Water Column			
	Sediment			
	Fish		22	
Delta Waterways (Eastern portion)	Water Column	2049		440
	Sediment	59		
	Fish		88	
Delta Waterways (Western portion)	Water Column	42		960
	Sediment	10		
	Fish		46	
Delta Waterways (Southern portion)	Water Column	396		623
	Sediment	10		
	Fish		124	
Delta Waterways (Northern portion)	Water Column	393		
	Sediment	40		
	Fish			
Delta Waterways (Central portion)	Water Column	351		
	Sediment	10		
	Fish		206	
Delta Waterways (Export area)	Water Column	257		
	Sediment			
	Fish			
Delta Waterways (Northwestern portion)	Water Column	510		
	Sediment	1146		
	Fish			

2.1.2 Data Analysis

Statistical analysis of data was performed with STATISTICA 6.2 (Statsoft Inc, 2008). This Report uses the arithmetic average for all data, as a measure of central tendency. Though some studies have used the median concentration (Davis et al, 2004), using the arithmetic mean incorporates samples with high contaminant concentrations and is thus more conservative for estimating maximum contaminant exposure.

Contaminant concentrations for both chlordanes and dieldrin were frequently below detection limits for a majority of samples. In these cases, it was not possible to run parametric power analyses. Nevertheless, high incidences of concentrations below detection limits, was interpreted as evidence of concentrations that don't pose a contamination threat, and, could be considered for possible lower management prioritization, as was done in the TMDL for Calleguas Creek (Total Maximum Daily Load for Organochlorine Pesticides, Polychlorinated Biphenyls, and Siltation in Calleguas Creek, Its Tributaries, and Mugu Lagoon) in Region 4 (Calleguas Creek TMDL, 2006).

2.1.3 Water, Sediment and Fish tissue Data

Summarized in Tables 4 and 5 are water column, sediment, and fish tissue data for the project area considering all years of available data.

2.1.3.1 Water Column

For water column data, DDT, DDD and DDE were considered independently, as the California Toxics Rule (CTR) has separate criteria for each of these constituents. CTR was used for the analysis, as it was the proposed water column target presented by Staff in Module 1 along with the non-detect basin plan objective for Organochlorines.

Data for DDT and its isomers was averaged based on continuous concentration (30-day average) for both human health and freshwater aquatic life protection. For dieldrin, chlordane and Alpha-HCH, a 4-day averaging period was used (US EPA, 2000a). For POTWs that have many non detects, the commonly employed practice of assuming one half the detection limit for non-detect values was employed. Efforts were taken during data analysis to note the reporting limits and quantitation limits for each study that had data used in the analysis.

Data was aggregated to assess detection frequencies and percent levels above the CTR criteria (Table 4). The aggregated detection frequencies provide an indication of how often individual pesticides have been detected in the impaired waterbody reaches. The reaches from Bear Creek to Mud Slough, Tuolumne River to Stanislaus River, Orestimba Creek (Above and Below Kilburn Road) as well as from Stanislaus River to the Delta Boundary had water column concentrations that were significantly ($P \leq 0.05$) below the CTR criteria (Table 4).

Numerous non-detects for various constituents were recorded for the following reaches: Merced River to Tuolumne River and Lower Tuolumne River. With the exception of

Lower Tuolumne River and Lower Stanislaus River, which did not depict any samples above the CTR criteria, other water body reaches showed values above the CTR criteria with percentage above ranging between 1-73%. On the overall, the margins of error were not significant and there was little variation in the data set as evidenced from the small standard deviations.

Water quality results for the Sacramento River basin were limited to Feather River (Table 4). There were no reported values above the CTR criteria with all data indicating either detections or high reporting limits. At a basin scale, the average detection rate in the water column was 100%. No non-detects were encountered suggesting that OC constituents were occurring frequently in the watershed. Most of the data were found to be less than the reporting limits.

The Sacramento-San Joaquin Delta water column results show that a higher number of samples were above the CTR criteria; specifically, the Delta Waterways Central Portion and the Eastern Portion (Table 5). These reaches also had a high number of non-detects.

2.1.3.2 Streambed Sediment

OC constituents were detected in streambed sediments. Data shows that the most frequently detected OCs were DDT, DDE, DDD, chlordane and dieldrin (Table 6). Staff was unable to obtain any streambed data for Category II constituents such as aldrin, endrin, heptachlor, heptachlor epoxide, methoxychlor, endosulfan, lindane, hexachlorohexanes (Alpha and Beta). Data in Table 6 shows that all sample counts were insufficient to perform power analysis.

Though several sediment target options were discussed in Module 1, it should be noted that for purposes of this preliminary source analysis work, sediment data was not compared to any threshold values or applicable guidelines. All bed sediment samples that registered as detects equally had high reporting limits. Data reported in Table 6 also indicates that many data samples (more than 70% of all samples) were subjected to analysis with high reporting limits. Numerous non-detects were recorded for the following reaches: Merced River to Tuolumne River, Tuolumne River to Stanislaus River, Lower Tuolumne River, as well as Stanislaus River to Delta Boundary. However, when considering all water body reaches, there were a number of detections resulting in an average detection rate of about 82% in the San Joaquin River basin for water column data.

In the Sacramento River basin (Table 7), sediment samples analyzed also had high reporting limits. On the contrary, results for the Sacramento-San Joaquin Delta (Table 8) showed no data values with high reporting limits and had about 60% detects in the Delta Waterways.

Though staff does not have the actual data to include in Table 6, the following study summary is provided as it occurred in the San Joaquin watershed portion of the project area. Brown (1997) collected samples of resident biota and bed sediments in 1992 from 18 sites on or near the floor of San Joaquin Valley for analysis of 33 OC pesticides. The sites were divided into five groups on the basis of physiographic region and land use. Two sites were chosen to represent conditions in the sloughs south of the west-side tributaries (Salt and Mud sloughs sites). Three sites were on the San Joaquin River, the first was above the majority of agricultural return flow to the river, the second was between the confluences of the Merced and Tuolumne rivers and the third was below the inputs of other streams sampled with the exception of the Mokelumne River, which flows directly into the Sacramento–San Joaquin Delta. DDT concentrations ranged from zero to 415 ppb. Over half of the detections were below 10 ppb. Sixteen sampling sites were located in areas where there was historical use of DDT. Only six sites had measurable levels of DDT present. Thirteen of the sites had measurable levels of DDE present. DDE/DDT ratios ranged from 1.9 to 5. This indicates the DDT present was probably from historical use. Brown (1997) concluded that concentrations of organochlorine pesticides in sediments may have declined from concentrations measured in the 1970s and 1980s in the San Joaquin Valley, but remained high when compared to other regions of the U.S.

Table 4. OC Impaired Reaches in the San Joaquin and Sacramento River Basin Above Minimum CTR Criteria, Number of Detections, Non-Detects and Lower than Reporting Limits in the Water Column (Percentages are followed by the number of samples in brackets)

Station Name	Constituent	Mean result	Number (n)1	Significant at P=0.05 for above CTR	Power Analysis sample size	% Above CTR Criteria (n)	% Detection (n)	% Non-Detect (n)	% with High Reporting Limits (#)
Bear Creek to Mud Slough	DDE	0.004±0.002	49	NS	3	4 (2)	96 (47)	-	96 (47)
	Lindane	0.004	66	S	Achieved	8 (5)	92 (61)	-	45 (30)
	Alpha-HCH	0.004±0.001	66	NS	4	5 (3)	67 (44)	-	45 (30)
Merced River to Tuolumne River	Dieldrin	-	42	-	-	-	-	100 (42)	-
	DDE	0.009±0.017	90	S	Achieved	14 (13)	36 (33)	22 (20)	36 (33)
	Lindane	0.004±0.002	84	S	Achieved	35 (29)	46 (39)	17 (14)	38 (32)
	Alpha-HCH	0.004±0.001	63	S	Achieved	16 (10)	79 (50)	-	79 (50)
Tuolumne River, Lower	Dieldrin	0.003±0.002	119	-	-	-	-	100 (119)	100 (119)
	DDE	0.005±0.001	117	-	-	-	-	100 (117)	100 (117)
	Lindane	0.004±0.002	119	-	-	-	100 (119)	-	100 (119)
	Alpha-HCH	0.003	119	-	-	-	100 (119)	-	100 (119)
Tuolumne River to Stanislaus River	Dieldrin	0.005	20	-	-	-	-	100 (20)	100 (20)
	DDE	0.002±0.002	20	No	6	5 (1)	-	95 (19)	95 (19)
	Lindane	0.003	20	Yes	Achieved	40 (8)	60 (12)	-	60 (12)
	Alpha-HCH	-	20	-	-	-	-	100 (20)	100 (20)
Merced River, Lower	Dieldrin	0.003±0.002	180	-	-	-	100 (180)	-	100 (180)
	DDE	0.004±0.001	93	S	Achieved	3 (3)	97 (90)	-	97 (90)
	Lindane	0.005±0.001	179	-	-	-	100 (179)	-	100 (179)
	Alpha-HCH	0.003	179	-	-	-	100 (179)	-	100 (179)
Orestimba Creek	Dieldrin	0.006±0.004	204	S	Achieved	42 (86)	58 (118)	-	58 (118)
	DDE	0.008±0.005	96	S	Achieved	73 (70)	27 (26)	-	27 (26)
	Lindane	0.005±0.003	200	S	Achieved	5 (9)	95 (191)	-	95 (191)
	Alpha-HCH	0.003±0.001	201	NS	5	1 (2)	99 (199)	-	99 (199)
Stanislaus River, Lower	Dieldrin	0.003±0.001	86	-	-	-	100 (86)	-	100 (86)
	DDE	0.004±0.001	86	-	-	-	100 (86)	-	100 (86)
	Lindane	0.004±0.001	86	-	-	-	100 (86)	-	100 (86)
	Alpha-HCH	0.004	86	-	-	-	100 (86)	-	100 (86)
Stanislaus River to Delta Boundary	Dieldrin	0.005±0.002	315	No	7	1 (3)	95 (299)	4 (13)	95 (298)
	Endrin	0.23	13	-	-	-	-	100 (13)	-
	Lindane	0.004	294	Yes	Achieved	3 (10)	97 (284)	-	97 (284)
	Alpha-HCH	0.003±0.002	293	No	6	1 (4)	99 (289)	-	99 (289)
	DDE	0.012±0.005	304	Yes	Achieved	15 (45)	82 (248)	4 (11)	82 (248)
	DDD	0.246±0.045	16	-	-	-	19 (3)	81 (13)	-
	DDT	-	18	-	-	-	-	100 (18)	-
Feather River	Dieldrin	0.0029±0.002	3	No	-	-	-	-	100 (3)
	Lindane	0.004±0.001	3	No	-	-	100 (3)	-	100 (3)
	DDE	0.005	3	No	-	-	-	-	100 (3)

[1] The number of samples is based on duration of averaged data (e.g. dieldrin data was assessed with a 30-day average) with comparison to 0.00014 µg/L as the CTR criteria for the protection of human health for consumption of water and organisms.
[2] The dash "-" indicates that there is NS data present for that parameter.

Table 5. OC Impaired Reaches in the Sacramento-San Joaquin Delta Above Minimum CTR Criteria, Number of Detections, Non-Detects and Lower than Reporting Limits in the Water Column (Percentages are followed by the number of samples in brackets)

Station Name	Constituent	Mean result	Number	Significant at P=0.05 for above CTR	Power Analysis sample size	% Above CTR Criteria (n)	% Detection (n)	% Non-Detect (n)	% with High Reporting Limits (#)
Delta Waterways-Central Portion	DDD(p,p')	0.759±0.405	54	Yes	Achieved	15 (8)	-	85 (46)	-
	DDE(p,p')	0.544±0.487	54	Yes	Achieved	22 (12)	-	78 (42)	-
	DDT(p,p')	0.458±0.485	54	Yes	Achieved	19 (10)	2 (1)	79 (43)	-
	DDD(o,p')	-	9	-	-	-	-	100 (9)	-
	DDE(o,p')	-	9	-	-	-	-	100 (9)	-
	DDT(o,p')	-	9	-	-	-	-	100 (9)	-
	Dieldrin	0.802±0.352	54	Yes	Achieved	15 (8)	-	85 (46)	-
	Endrin	0.655±0.484	54	Yes	Achieved	15 (8)	2 (1)	83 (45)	-
Delta Waterways-Eastern Portion	DDD(p,p')	0.356±0.271	266	Yes	Achieved	6 (16)	-	94 (250)	-
	DDE(p,p')	0.320±0.287	254	Yes	Achieved	5 (14)	1 (1)	94 (239)	-
	DDT(p,p')	0.339±0.311	272	Yes	Achieved	6 (16)	1 (1)	93 (255)	-
	DDD(o,p')	0.028±0.010	129	Yes	Achieved	5 (6)	-	95 (123)	-
	DDE(o,p')	0.025±0.009	129	Yes	Achieved	5 (6)	-	95 (123)	-
	DDT(o,p')	0.089±0.160	129	Yes	Achieved	5 (6)	-	95 (123)	-
	Dieldrin	0.286±0.301	254	Yes	Achieved	6 (16)	1 (1)	93 (237)	-
	Endrin	0.369±0.311	255	Yes	Achieved	5 (14)	-	95 (241)	-
Delta Waterways-Export Area	DDD(p,p')	0.572±0.124	39	Yes	Achieved	8 (3)	-	92 (36)	-
	DDE(p,p')	0.250±0.306	37	Yes	Achieved	11 (4)	-	89 (33)	-
	DDT(p,p')	0.452±0.296	40	Yes	Achieved	10 (4)	-	90 (36)	-
	Dieldrin	0.594±0.100	40	Yes	Achieved	8 (3)	-	92 (37)	-
	Endrin	0.657±0.020	40	Yes	Achieved	8 (3)	-	92 (37)	-
Delta Waterways-Northern Portion	DDD(p,p')	0.539±0.103	59	Yes	Achieved	14 (8)	-	86 (51)	-
	DDE(p,p')	0.515±0.099	59	Yes	Achieved	14 (8)	-	86 (51)	-
	DDT(p,p')	0.466±0.236	59	Yes	Achieved	14 (8)	1 (1)	85 (50)	-
	DDD(o,p')	-	13	-	-	-	-	100 (13)	-
	DDE(o,p')	-	13	-	-	-	-	100 (13)	-
	DDT(o,p')	-	13	-	-	-	-	100 (13)	-
	Dieldrin	0.560±0.907	59	Yes	Achieved	14 (8)	-	86 (51)	-
	Endrin	0.548±0.146	59	No	6	4 (2)	10 (6)	86 (51)	-
Delta Waterways-Northwest Portion	DDD(p,p')	0.539±0.111	68	Yes	Achieved	6 (4)	-	94 (64)	-
	DDE(p,p')	0.516±0.106	68	Yes	Achieved	6 (4)	-	94 (64)	-
	DDT(p,p')	0.420±0.281	68	Yes	Achieved	6 (4)	1 (1)	93 (63)	-
	DDD(o,p')	-	26	-	-	-	-	100 (26)	-
	DDE(o,p')	-	26	-	-	-	-	100 (26)	-
	DDT(o,p')	-	26	-	-	-	-	100 (26)	-
	Dieldrin	0.561±0.103	68	Yes	Achieved	6 (4)	-	94 (64)	-
	Endrin	0.549±0.158	68	Yes	Achieved	6 (4)	-	94 (64)	-
Delta Waterways-Southern Portion	DDD(p,p')	0.551±0.904	61	Yes	Achieved	8 (5)	-	92 (56)	-
	DDE(p,p')	0.315±0.295	61	Yes	Achieved	11 (7)	4 (2)	85 (52)	-
	DDT(p,p')	0.430±0.287	60	Yes	Achieved	10 (6)	-	90 (54)	-
	Dieldrin	0.492±0.247	61	Yes	Achieved	8 (5)	2 (1)	90 (55)	-
	Endrin	0.624±0.047	61	Yes	Achieved	8 (5)	-	92 (56)	-
Delta Waterways-Western Portion	DDD(p,p')	-	7	-	-	-	-	100 (7)	-
	DDE(p,p')	0.053±0.048	7	No	5	29 (2)	14 (1)	57 (4)	-
	DDT(p,p')	0.034±0.029	7	No	7	29 (2)	-	71 (5)	-
	Dieldrin	-	7	-	-	-	-	100 (7)	-
	Endrin	0.010	7	No	4	14 (1)	-	86 (6)	-

Note: The dash "-" indicates that there is no data present for that parameter.

Table 6. OC Impaired Reaches in the San Joaquin River Basin showing Number of Detections, Non-Detects and Lower than Reporting Limits for Bed Sediment <2mm. (Percentages are followed by the number of samples in brackets)

Station Name	Constituent	Mean result	Number	Significant at P=0.05?	Power Analysis sample size	# Detection	# Non-Detect	High Reporting Limits
Bear Creek to Mud Slough	Dieldrin	1	1	No	-	100 (1)	-	100 (1)
	Chlordane	1	3	No	-	100 (3)	-	100 (3)
	o,p'-DDD	1	1	No	-	100 (1)	-	100 (1)
	o,p'-DDE	1	1	No	-	100 (1)	-	100 (1)
	o,p'-DDT	2	1	No	-	100 (1)	-	100 (1)
	p,p'-DDD	1	1	No	-	100 (1)	-	100 (1)
	p,p'-DDE	1	1	No	-	-	-	-
	p,p'-DDT	2	1	No	-	100 (1)	-	100 (1)
Merced River to Tuolumne River	Dieldrin	1	1	No	-	100 (1)	-	100 (1)
	Chlordane	1	3	No	-	100 (3)	-	100 (3)
	o,p'-DDD	1	1	No	-	100 (1)	-	100 (1)
	o,p'-DDE	1	1	No	-	100 (1)	-	100 (1)
	o,p'-DDT	1	1	No	-	100 (1)	-	100 (1)
	p,p'-DDD	1	1	No	-	100 (1)	-	100 (1)
	p,p'-DDT	1	1	No	-	-	-	-
Lower Merced	Dieldrin	1	1	No	-	-	-	-
	Chlordane	1	3	No	-	-	-	-
	o,p'-DDD	1	1	No	-	-	-	-
	o,p'-DDE	1	1	No	-	-	-	-
	o,p'-DDT	2	1	No	-	-	-	-
	p,p'-DDD	1	1	No	-	-	-	-
	p,p'-DDT	2	1	No	-	-	-	-
Orestimba Creek	Dieldrin	1	1	No	-	-	-	-
	Chlordane	2	1	No	-	50 (1)	-	50 (1)
	p,p'-DDT	2	1	No	-	100 (1)	-	100 (1)

Table.7. OC Pesticide Impaired Reaches in the Sacramento River Basin showing Number of Detections, Non-Detects and Lower than Reporting Limits for Bed Sediment <2mm. (Percentages are followed by the number of samples in brackets)

Station Name	Pollutant	Mean result	Number	Significant at P=0.05?	Power Analysis sample size	# Detection	# Non-Detect	<Reporting Limits
Colusa Basin Drain	DDD(p,p')	1.9	1	No	-	100 (1)	-	-
	DDE(p,p')	5.4	1	No	-	-	-	-
	DDT(p,p')	2	1	No	-	-	-	100 (1)
	Dieldrin	1	1	No	-	-	-	100 (1)
	Endrin	2	1	No	-	-	-	100 (1)
	Hexachlorobenzene	50	1	No	-	-	-	100 (1)
	Lindane	1	1	No	-	-	-	100 (1)
	Alpha-HCH	1	1	No	-	-	-	100 (1)
	DDD	1	1	No	-	-	-	100 (1)
	DDE(o,p')	1	1	No	-	-	-	100 (1)
	DDT(o,p')	2	1	No	-	-	-	100 (1)
	Heptachlor Epoxide	1	1	No	-	-	-	100 (1)
	Oxychlordane	1	1	No	-	-	-	100 (1)
	Toxaphene	200	1	No	-	-	-	100 (1)
	Nonachlor	1	1	No	-	-	-	100 (1)
	Aldrin	1	1	No	-	-	-	100 (1)
	Alpha Endosulfan	1	1	No	-	-	-	100 (1)
	beta-HCH	1	1	No	-	-	-	100 (1)
	cis-Chlordane	1	1	No	-	-	-	100 (1)
	cis-Nonachlor	1	1	No	-	-	-	100 (1)
	Heptachlor	1	1	No	-	-	-	100 (1)
	Methoxychlor (o,p')	5	2	No	-	-	-	100 (2)
Feather River	DDD(p,p')	1	1	No	-	-	-	100 (1)
	DDE(p,p')	1	1	No	-	-	-	100 (1)
	DDT(p,p')	2	1	No	-	-	-	100 (1)
	Dieldrin	1	1	No	-	-	-	100 (1)
	Endrin	2	1	No	-	-	-	100 (1)
	Hexachlorobenzene	1	1	No	-	-	-	100 (1)
	Lindane	1	1	No	-	-	-	100 (1)
	Alpha-HCH	1	1	No	-	-	-	100 (1)
	DDD(o,p')	1	1	No	-	-	-	100 (1)
	DDE(o,p')	1	1	No	-	-	-	100 (1)
	DDT(o,p')	2	1	No	-	-	-	100 (1)
	Heptachlor Epoxide	1	1	No	-	-	-	100 (1)
	Oxychlordane	1	1	No	-	-	-	100 (1)
	Toxaphene	200	1	No	-	-	-	100 (1)
	Nonachlor	1	1	No	-	-	-	100 (1)
	Aldrin	1	1	No	-	-	-	100 (1)
	Alpha Endosulfan	1	1	No	-	-	-	100 (1)
	beta-HCH	1	1	No	-	-	-	100 (1)
	cis-Chlordane	1	1	No	-	-	-	100 (1)
	cis-Nonachlor	1	1	No	-	-	-	100 (1)
	Heptachlor	1	1	No	-	-	-	100 (1)
	Methoxychlor (o,p')	5	2	No	-	-	-	100 (2)
	Chlordane	1	1	No	-	-	-	100 (1)

Table.8. OC Pesticide Impaired Reaches in the Sacramento-San Joaquin Delta showing Number of Detections, Non-Detects and Lower than Reporting Limits in Suspended Sediment (Percentages are followed by the number of samples in brackets).

Station Name	Pollutant	Mean result	Number	Significant at P=0.05?	Power Analysis sample size	# Detection	# Non-Detect	High Reporting Limits
Delta Waterways-Central Portion	DDD(p,p')	-	1	-	-	-	100 (1)	-
	DDE(p,p')	3.7	1	-	-	-	-	-
	DDT(p,p')	2.23	1	-	-	-	-	-
	Dieldrin	-	1	-	-	-	100 (1)	-
	Endrin	-	3	-	-	-	100 (3)	-
	Chlordane	-	2	-	-	-	100 (2)	-
Delta Waterways-Eastern Portion	DDD(p,p')	1.23	7	Yes	Achieved	14 (1)	86 (6)	-
	DDE(p,p')	6.95±5.72	6	Yes	Achieved	17 (1)	66 (4)	-
	DDT(p,p')	3.88±1.39	7	Yes	Achieved	14 (1)	14 (1)	-
	Dieldrin	1.38	6	Yes	Achieved	17 (1)	83 (5)	-
	Endrin	-	18	Yes	Achieved	-	100 (18)	-
	Chlordane	-	5	Yes	Achieved	-	100 (5)	-
Delta Waterways-Northern Portion	DDD(p,p')	-	4	Yes	Achieved	-	100 (4)	-
	DDE(p,p')	2.0375±1.13	4	Yes	Achieved	50 (2)	-	-
	DDT(p,p')	3.6675±2.14	4	Yes	Achieved	-	-	-
	Dieldrin	1.3	4	Yes	Achieved	25 (1)	75 (3)	-
	Endrin	-	12	Yes	Achieved	-	100 (12)	-
	Chlordane	-	8	Yes	Achieved	-	100 (8)	-
Delta Waterways-Northwest Portion	DDD(p,p')	-	3	-	-	-	100 (3)	-
	DDE(p,p')	1.483±0.274	3	No	6	100 (3)	-	-
	DDT(p,p')	4.147±2.343	3	No	5	100 (3)	-	-
	Dieldrin	1.300	3	No	6	33 (1)	67 (2)	-
	Endrin	-	9	-	-	-	100 (9)	-
	Chlordane	-	6	-	-	-	100 (6)	-
Delta Waterways-South	DDD(p,p')	-	1	-	-	-	100 (1)	-
	DDE(p,p')	2.12	1	-	-	100 (1)	-	-
	DDT(p,p')	3.17	1	-	-	100 (1)	-	-
	Dieldrin	-	1	-	-	-	100 (1)	-
	Endrin	-	3	-	-	-	100 (3)	-
	Chlordane	-	2	-	-	-	100 (2)	-
Delta Waterways-West	DDD(p,p')	-	1	-	-	-	100 (1)	-
	DDE(p,p')	3.7	1	-	-	100 (1)	-	-
	DDT(p,p')	2.23	1	-	-	100 (1)	-	-
	Dieldrin	-	1	-	-	-	100 (1)	-
	Endrin	-	3	-	-	-	100 (3)	-
	Chlordane	-	2	-	-	-	100 (2)	-

2.1.3.3 Fish Tissue

Fish tissue data throughout this Attachment are reported as µg/kg on a wet weight basis as composite samples for each species. For fish and aquatic tissue samples, both DDT and chlordane data were derived as the summation of the respective isomers for each composite sample. All other OC constituents were considered as single compounds. Total DDTs were calculated by summing the concentrations of isomers p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, and o,p'-DDD. Total chlordanes were calculated by summing the concentrations of cis-chlordane, trans-chlordane, and oxychlordane.

For fish tissue data, length and age were not adjusted in the analyses. For analysis of long-term trends in OC constituents, lipid-normalized concentrations of OC constituents were assessed on a lipid weight basis which adjusts the data for variation due to lipid content and thus makes temporal trends more evident. The lipid-normalized concentration, Cl, of a chemical in fish tissue is defined using equation (3):

Equation (3): $$C_l = \frac{C_B}{f_l}$$

Where: C_B=concentration of the organic chemical in the tissue of aquatic biota (either whole organism or specified tissue) (µg/g),

f_l=fraction of the tissue that is lipid.

In Module 1, Staff presented several options for fish tissue targets. As an example for this Attachment, Staff selected three OC constituents DDT, chlordane and dieldrin and opted to use four options as thresholds for fish tissue data. The four options were: OEHHA 2008 Fish Contaminant Goals (FCGs), OEHHA 1999 Screening Values (SVs), Tissue Threshold Residue Levels (TTRLs) (Calleguas Creek, 2006) and Advisory Tissue Levels (ATLs) with three consumptions levels: three 8-ounce meals/week, two 8-ounce meals/week and one 8-ounce meal/week (OEHHA, 2008). Selection of the above mentioned 3 OC constituents or the four options was provided as an example and does not preclude further analysis of other OC constituents or any other possible options from future consideration as targets. With the aforementioned ranges of options, Staff opted to present graphs for fish tissue data instead of tables to provide better visual comparisons (Figures 1, 2 and 3).

The discussion that follows is in reference to Figures 1, 2 and 3. Worth noting are the variation in scales for each of the three OC constituents. Some scales for the concentration levels (Y-axis) have an axis-break to allow a better visual representation for lower OC levels. The trends in Figures 1, 2 and 3 also depict pollutant concentration differences in fish tissue with DDT having an order of magnitude higher than Chlordane and an extra order of magnitude higher in Dieldrin. (Where possible, Figures 1, 2, and 3 are best viewed in color).

2.1.3.3a San Joaquin River Basin

For the San Joaquin River Basin, approximately 90% of DDT fish tissue concentrations were above the OEHHA 2008 FCG for DDT of 21 µg/kg and the TTRL value of 31.2 µg/kg (Figure 1a). Sites that had fish with notable high levels of tissue DDT were the Merced River at Hagaman County Park (White Catfish, Carp and Channel Catfish), the Merced River at Hatfield Station Recreation Area (Largemouth Bass and Channel Catfish), San Joaquin River at Vernalis (Channel catfish and white catfish), Orestimba Creek at Bell Road (Golden Shiner - collected in 1990 and had the highest recorded DDT tissue concentration of 7,267 µg/kg which was above the ATL one 8-oz meal/week), Orestimba Creek at River Road (Asiatic Clam), Lower Tuolumne River (Sacramento Sucker, White Catfish and Channel Catfish) as well as Tuolumne River at Shiloh Road (Largemouth Bass). On the contrary, a few sites (Figure 1a) had fish tissue data below the OEHHA 2008 FCG of 21 µg/kg for tissue DDT. These locations were Mendota Pool with Channel Catfish and Tuolumne River at Modesto with Asiatic Clam.

Chlordane fish tissue revealed that about 85% of the samples were above the OEHHA 2008 chlordane FCG of 5.6 µg/kg, about 80% were above the TTRL value of 8.04 µg/kg with most samples falling below the OEHHA 1999 SV of 30 µg/kg (Figure 1b). Monitoring stations with fish tissue that had notably high values of chlordane included lower Tuolumne River (large mouth bass), SJR at Vernalis (Channel catfish and Asiatic Clam), lower Stanislaus River (Largemouth bass). The monitoring stations with fish that had the lowest chlordane body burdens were SJR at Crows Landing (Sacramento Sucker and Largemouth Bass) and the Tuolumne River at Shiloh Road (Golden Shiner). No fish tissue sample values were above ATL levels (Figure 1b).

Dieldrin fish tissue revealed than > 95% of the samples were above the OEHHA 2008 dieldrin FCG of 0.46 µg/kg, and about 80% were above the TTRL value of 0.65 µg/kg (Figure 1c). Notably higher dieldrin tissue levels were found in samples from SJR at Fremont Ford (Asiatic Clam), Orestimba Creek at River Road (Asiatic Clam), and Orestimba Creek at Bell Road (Golden Shiner). There were numerous data samples that had non-detects and several samples with concentrations below the threshold FCG thresholds for dieldrin in fish tissue.

2.1.3.3b Sacramento River Basin

Fish in the Sacramento River basin were collected from sites in the Colusa Basin Drain and from the Feather River (Figure 2a). For DDT, areas with high fish body burdens that were above the OEHHA 2008 FCG, TTRLs and the 1999 SV included the Colusa Basin Drain at Road 99E near Knights Landing (Carp), Colusa Basin Drain at Abel Road (Carp and Brown Bullhead), Colusa Basin Drain at Knights Landing (Carp, Channel Catfish and White Catfish), and Feather River @ Highway 99 (Channel Catfish) (See Figure 2a).

Chlordane fish tissue samples that had high body burdens included the Colusa Basin Drain (Largemouth Bass), Colusa Drain at Abel Road (Brown Bullhead), and the Feather River at Highway 99 (Channel Catfish), which had the highest (above the OEHHA FCGs, OEHHA 1999 SV and TTRLs but below all ATLs) levels compared to other sites (Figure 2b).

Dieldrin fish tissue samples that had high body burdens (above the OEHHA 2008 FCG, OEHHA 1999 SV and TTRLs) were from the Colusa Basin Drain at Road 99E (Carp), Colusa Basin Drain at Abel Road (Carp, Channel catfish and Brown Bullhead) and the Colusa Basin Drain at Knights Landing (Carp and Channel Catfish) and Feather River @ Highway 99 (Channel Catfish) (Figure 2c).

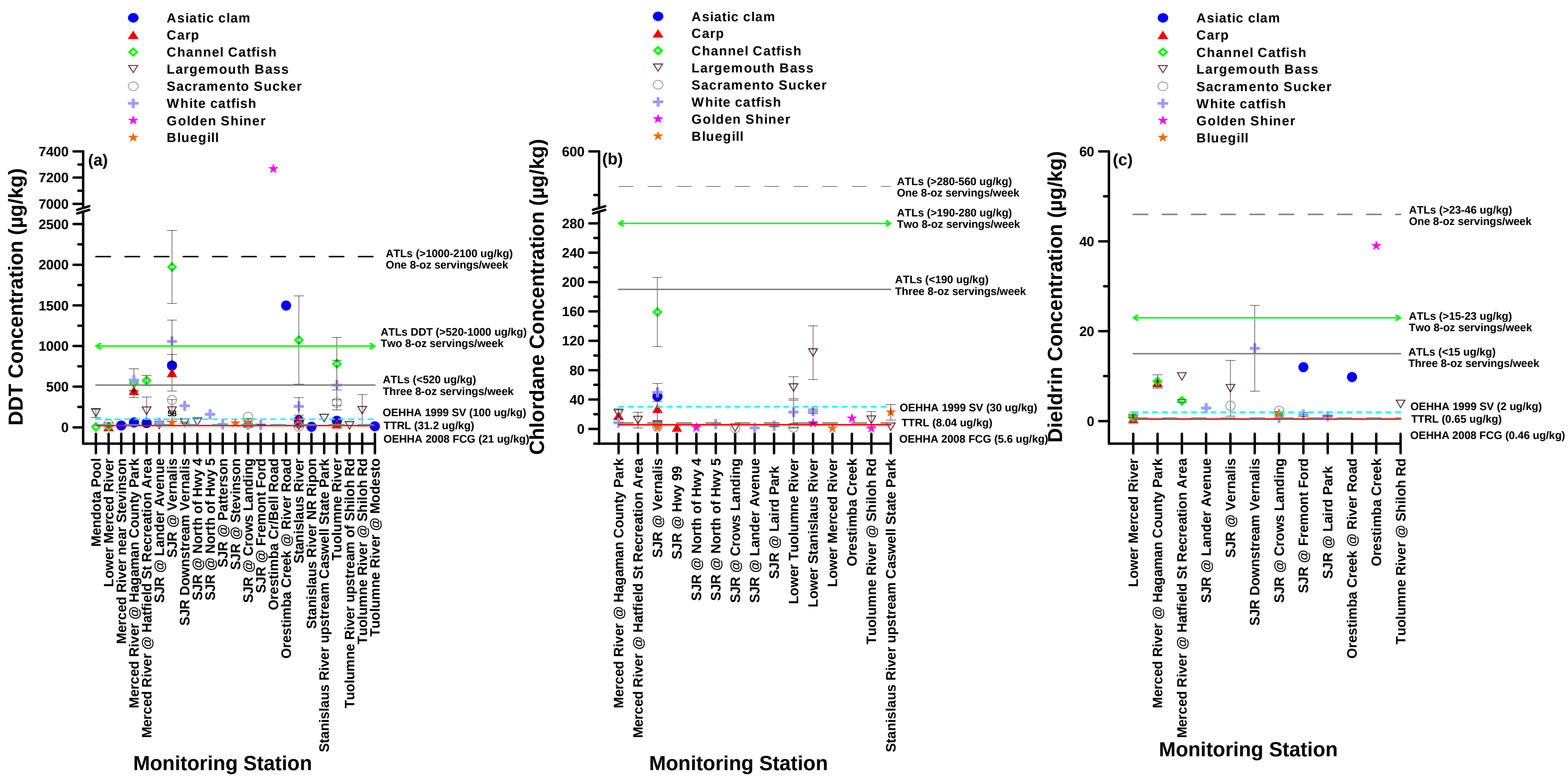

Figure 1. OC Pesticides in fish tissue for the San Joaquin River Basin, 1978-2008 (Numerous data sources)

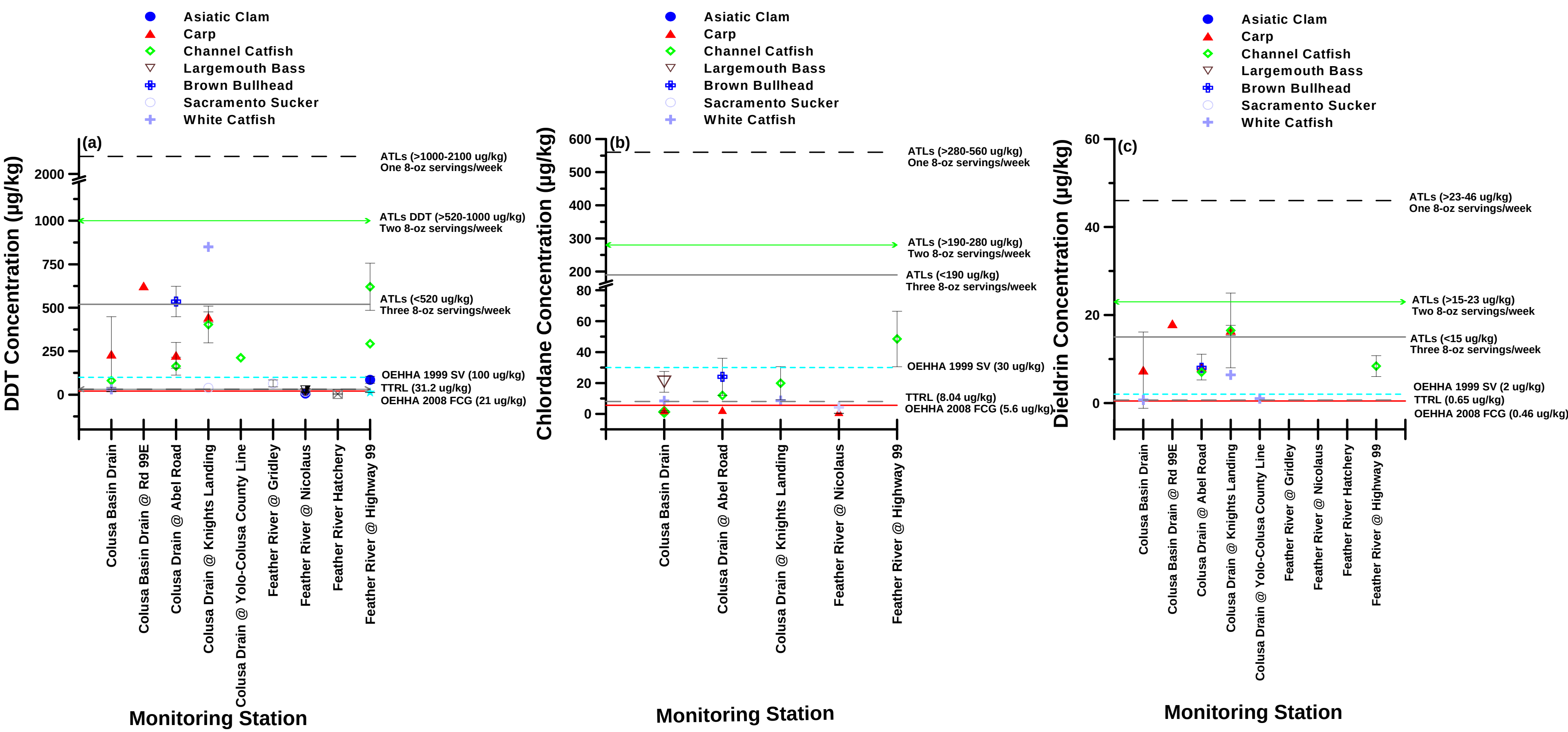

Figure 2. OC Pesticides in fish tissue for the Sacramento River Basin, 1978-2008 (Numerous data sources)

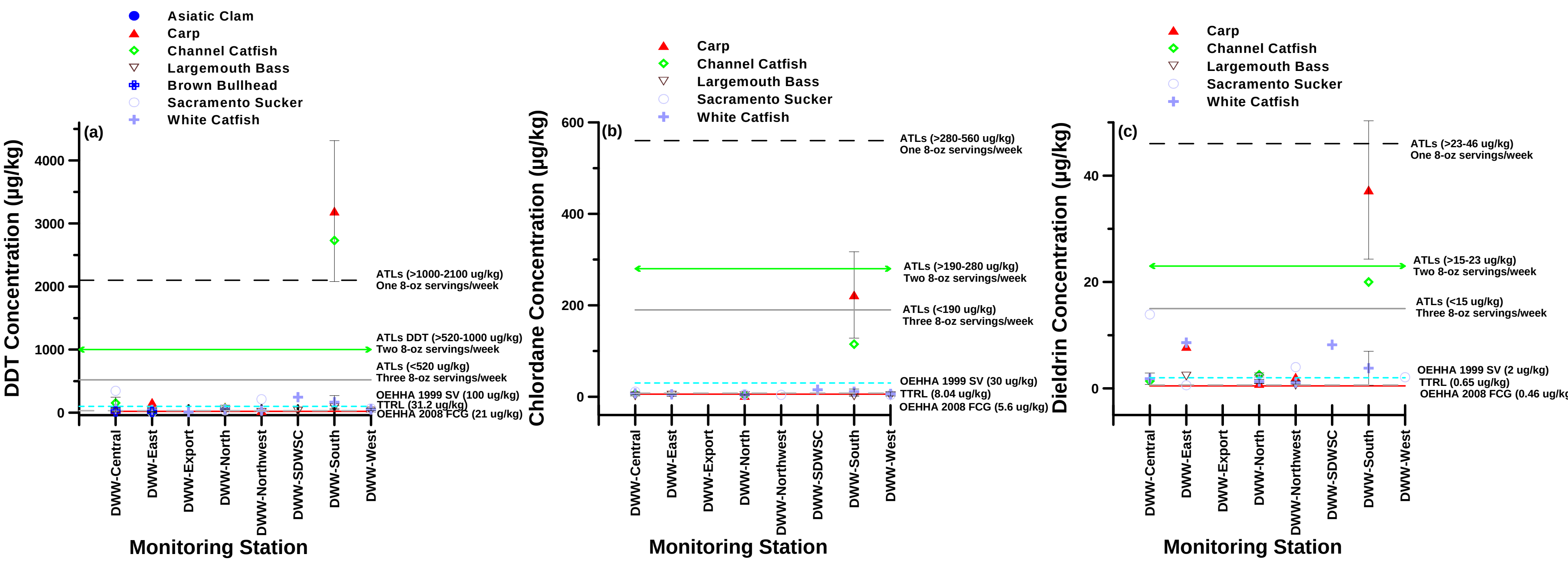

Figure 3. OC Pesticides in fish tissue for the Sacramento-San Joaquin Delta, 1978-2008 (Numerous data sources)

2.1.3.3c Sacramento-San Joaquin Delta

Greater than 95 % of fish tissue samples were above the OEHHA 2008 FCG for DDT of 21 µg/kg and the TTRL value of 31.2 µg/kg (Figure 3a). For DDT, fish tissue with body burden below OEHHA 2008 FCG for DDT of 21 µg/kg and the TTRL value of 31.2 µg/kg were Channel Catfish at Delta Waterways Eastern Portion and White Catfish at Delta Waterways Export area. Fish tissue that recorded the highest body burdens were the Delta Waterways Stockton DWSC and the Delta Waterways Southern Portion, specifically at Paradise Cut at Tracy (Delta Waterways southern portion) with a mean average tissue concentration of 3,197 µg/kg for Carp and a mean average tissue concentration of 2,731 µg/kg for Channel Catfish. Note that the high concentrations with no axis breaks and large standard errors diminish visibility of concentrations at lower levels (Figure 3a).

For chlordane, about 90% of fish tissue samples were below the OEHHA 2008 FCG for chlordane of 5.6 µg/kg and the TTRL value of 8.04 µg/kg. These included samples from Delta Waterways Eastern Portion, Northern Portion, Southern Portion, and Western Portion. For example Delta Waterways Eastern Portion, Largemouth Bass at Sycamore Slough near Mokelumne River and White Catfish at Calaveras River, and Smith Canal were below the OEHHA FCG thresholds. Fish composite samples at the Calaveras River and Smith Canal were less than the reporting limits (Figure 3b).

For dieldrin, all fish tissue samples were above the OEHHA 2008 FCG for dieldrin of 0.46 µg/kg and the TTRL value of 0.65 µg/kg (Figure 3c). Outstanding chlordane fish tissue body burdens were identified in the Delta Waterways Southern Portion at Paradise cut at Tracy for Carp (37.3 µg/kg) and Channel Catfish (20 µg/kg) (Figure 3c).

2.1.3.3d Temporal Fish Tissue Variations

Temporal trends provide a better perspective for data presented in Figures 1, 2 and 3 above as to whether OC constituents in fish tissue are constant, increasing or decreasing. Lipid content in fish tissue is reported as an important driver of variation in organic contaminant concentrations in both space and time (Larsson et al. 1993) and helps assess temporal trends. Previous studies have documented a significant relationship between tissue lipid content and OC concentrations (Larsson et al. 1993). As an example, for channel catfish tissue samples in the Merced River to Tuolumne River reach, statistical evaluations of long-term trends were performed by computing the Spearman rank correlation coefficient for exponential model decay curve fits of the lipid normalized average OC concentration versus year (As per Section 2.1.2 Data Analysis, see Equation 3).

For analysis of long-term trends in OC constituents, lipid-normalized concentrations of OC constituents were assessed on a lipid weight basis which adjusts the data for variation due to lipid content and thus makes temporal trends more evident. All lipid-normalized data had an exponential decay pattern as shown by the model fits to the data (Fig. 4) of the form shown in equation (4):

Equation (4): *ln(y) = b*X+c*

Where:
y = the lipid normalized OC pesticide concentration;
b and c = empirical constants and
X = time.

The data indicates that OCs have been declining since the late 1970s to the present day. The lipid-normalized concentration for DDT, chlordane, and dieldrin of recently caught Channel Catfish in that reach (Merced River to Tuolumne River) is significantly lower than the lipid-normalized concentrations from historic data (Fig. 4).

Similar to Figures 1, 2 and 3, the temporal trends in Fig. 4 also depict pollutant concentration differences in fish tissue with DDT having an order of magnitude higher than Chlordane and an extra order of magnitude higher in Dieldrin. The exponential model curve fits were projected to the year 2020 to observe the fate and gradual natural attenuation of OC constituents in fish tissue if no remediation action were taken. The data indicates an apparent decline to near non-existance by the year 2020. However, it should be noted that this is based on the assumption that other variables that could re-introduce OC constituents such as re-excavation, re-suspension or atmospheric deposition do not occur in these watersheds. However, staff feels these processes are likely to occur so levels of low levels of OCs may still be present after 2020.

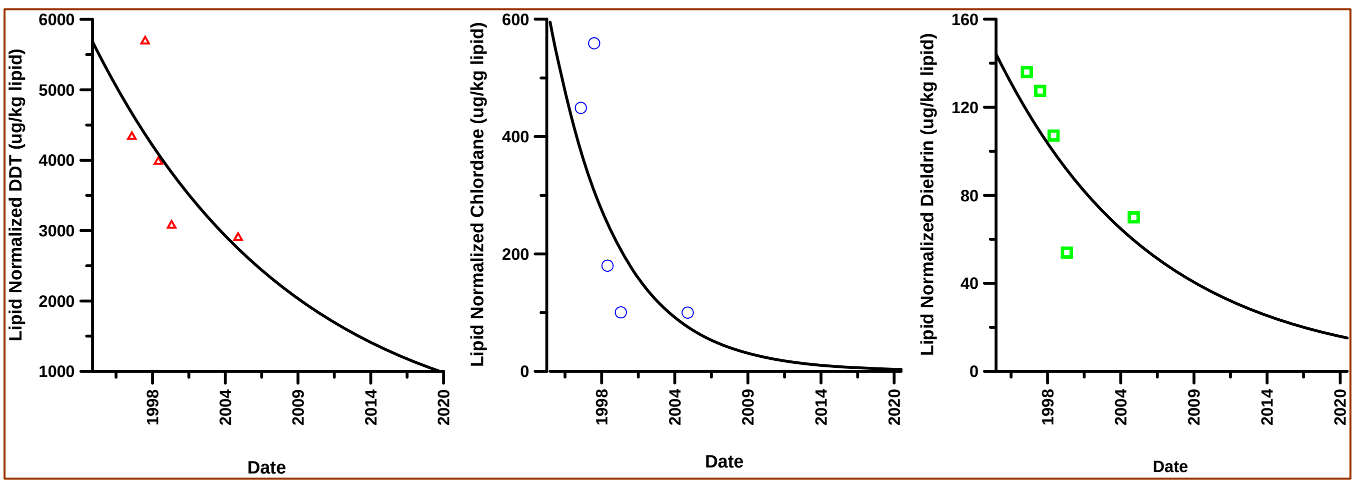

Figure 4. Temporal variation of Lipid normalized OCs for Channel catfish (Merced River to Tuolumne River reach) (1978-2005).

Despite the temporal decline trends, present findings still indicate that there are significant concentrations which persist in numerous locations within the Central Valley. OC constituents detected in the water column, stream sediment and fish tissue could reflect a combination of environmental persistence as well as the degree of historical use.

Staff continues to evaluate regional data on spatial and temporal trends of OC constituents in all three media (fish tissue, water column and sediment) in order to present all the data associated with each of the impaired 21 waterbody reaches in the Central Valley watersheds for the Staff Report.

3. Source Analysis

Current sources of OCs are predominantly related to their historic applications in agricultural, urban settings. Potential sources for OCs in the project area could be point sources (such as wastewater treatment plant discharges, stormwater, and historic spills), nonpoint sources (such as agricultural lands, open space and channel erosion), as well as wet and dry deposition. With most of the OCs previously deposited on terrestrial soils, erosion and transport of these contaminated sediments continues to contribute to detectable levels in stream bed sediment. Currently available data in the Central Valley reveals presence of OCs in the water column, sediment and fish tissue. Some of the potential OC sources are portrayed in a conceptual model (Fig. 5). This section describes potential sources and some losses of OCs in Central Valley watersheds.

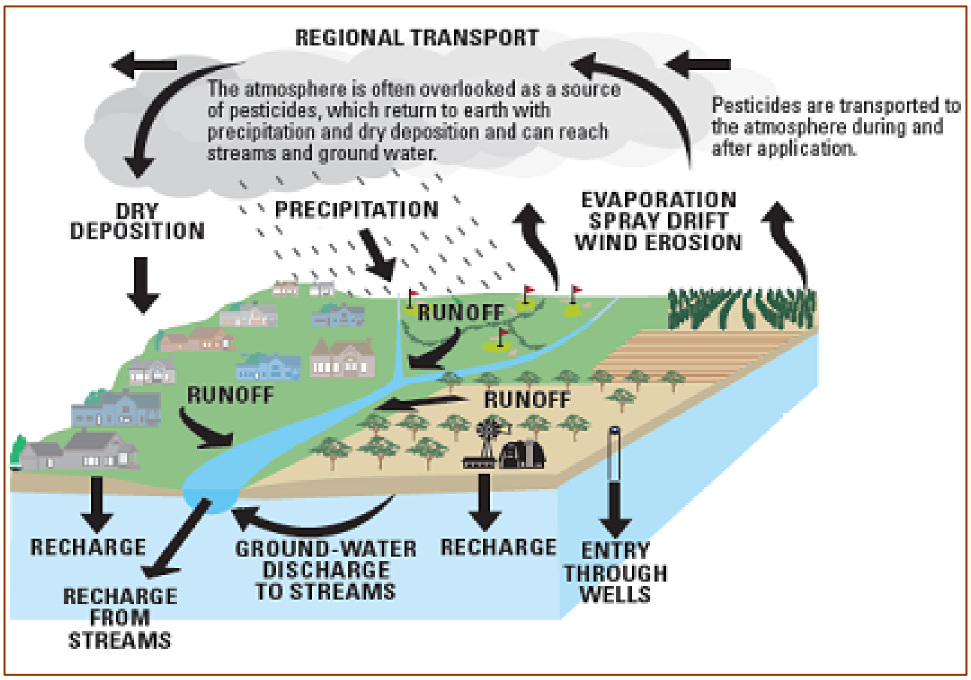

Figure. 5. Conceptual illustration for OC pesticide transportation (Modified after USGS, 2007)

3.1 Background Sources

There are no natural background sources of OCs as all OCs are manmade chemicals. Since OCs are not natural pollutants, background levels of these pesticides would not be expected in absence of their use. Unlike some naturally occurring compounds such as selenium, there are no natural sources of OCs, and there are no natural, or “background” concentrations.

3.2 Atmospheric Deposition

Although the use of DDT is no longer permitted in the United States, it may be released to the atmosphere from neighboring and far away countries where manufacture and use continue. OC pesticides, including DDT have the potential for long-range atmospheric transport and contamination of migratory wildlife spending parts of their lives in countries were OC pesticides are still in use (Nowell et al., 1999). Mexico, USA's neighboring country to the south, unveiled a program designed to phase out all uses of the pesticides DDT and Chlordane by 2007 (EHP, 1997). It is likely that since DDT is semi-volatile, it may volatilize from far away hot regions then condense and tend to remain in colder regions (Ritter et al., 1995). This property confers on OCs including DDT the capacity to be transported over long distances. DDT, DDE, and DDD may also enter the air when local residues volatize from contaminated water and soil in a process referred to as gaseous evasion (See Figure 5). Wind erosion of soils and sediments containing sorbed residues can also play a key role. As a result, OC pesticides are deposited from the atmosphere during precipitation events (wet deposition) as well as from pesticide drift and settling from the atmosphere due to gravity (dry deposition).

There are currently no known studies to staff conducted on atmospheric deposition in any of the watersheds of the 21 waterbody reaches. Some studies on atmospheric deposition have been conducted in California National Parks by Hageman et al., 2006 and Bradford et al., 2010, however, atmospheric deposition rates for OC pesticides were not provided in these studies. Studies carried out by the New Jersey Atmospheric Deposition Network (NJADN) revealed atmospheric deposition rates for some of the OC pesticides. Atmospheric deposition rates for OCs were calculated using Henry's Law constant and methods from Mackay et al 1999. These studies report atmospheric deposition results that were comparable to other similar studies conducted in North America and the Great Lakes Region (Cortes et al 1998; Bidleman et al., 2002).

Wet and dry deposition rates for DDT, DDE, DDE, alpha-chlordane, and gamma-chlordane were estimated for the Central Valley Watersheds using concentrations from the NJADN in conjunction with local data for rainfall, theoretical deposition velocity, and watershed area. Although various differences in climatic and land use conditions generate some uncertainty about the appropriateness of using the NJADN study, no other studies are known to have been completed in more comparable geographic regions to the Project Area. The approach is presented below.

Wet deposition and dry deposition loading (lbs/yr) can be calculated as-

Equation (5)
Wet Deposition Loading (lbs/yr):
C * Vrain * A
Where:
C = pesticide concentration in rain (dissolved plus particulate) [1]
Vrain = average annual rainfall (14.75 in/yr) [2]
A = Watershed Area (32894.25 sq. miles)

Equation (6)
Dry Deposition Loading (lbs/yr):
C * Vdep * A
Where:
C = atmospheric particulate concentration [1]
Vdep = theoretical deposition velocity [3]
A = Watershed Area (32894.25 sq. miles)

[1] Data from NJADN used to approximate concentrations in Central Valley Watersheds
[2] Average from National Climatic Data Center (NCDC) for Merced, Sacramento and Stockton annual precipitation (NCDC, 2010).

[3] Theoretical deposition velocity of 0.175 cm/sec (value used to estimate atmospheric deposition of salts to the Calleguas creek watershed (Calleguas TMDL, 2006).

In order to better estimate actual dry deposition in Central Valley watersheds, atmospheric particulate concentrations presented in the NJADN studies were normalized according to PM_{10} data from New Jersey (NJDEP, 2010) and that for Central Valley watersheds (CVWs) in California as prescribed by California Air Resources Board (PM_{10} data measures the amount of airborne particulate matter 2.5-10 micrometers in size). The method is shown in the equation below.

Equation (7):
Dry Deposition in CVW = [C NJADN * PM10cvw / PM_{10} NJADN]*Vdep * Acvw
Equation 7 was derived from similar work done for the Calleguas Creek in Southern California (Calleguas Creek TMDL, 2006). The PM_{10} for New Jersey particulate matter is 50 µg/m^3 (NJDEP, 2010) and that for California is 20 µg/m^3 (California Air Resources Board, 2009).

It should be noted that Table 9 estimates are reported in total pounds of deposition per year across all land and water areas of the Central Valley Watershed. This method over predicts the actual contribution of OCs to water resulting from aerial deposition since only a portion of all OCs deposited on land actually reach water (due to degradation which occurs before the OCs are released from terrestrial soils by erosion). The extent of this over prediction is dependant on sorption and climatic characteristics which in turn determine the rate and extent of degradation (Mackay, 1999).

Table 9. Atmospheric deposition rates for OC constituents upon total land and water surface area in the Central Valley Watersheds using estimates from the NJADN studies, normalized according to Central Valley watersheds PM_{10} data.

Constituent	Atmospheric Deposition Fluxes (ng m^{-2} d^{-1})		Estimated Atmsopheric Input (lb/yr)		Total (lb/yr)
	Wet	**Dry**	**Wet**	**Dry**	
ΣDDT	0.61	1.15	1.69	5.52	7.21
Dieldrin	-	1.2	-	5.76	5.76
Aldrin	-	0.1	-	0.48	0.48
Endosulfan I	0.35	0.45	0.97	2.16	3.13
Endosulfan II	1.38	1.07	3.82	5.13	8.96
Endosulfan Sulfate	1.02	0.51	2.83	2.45	5.27
Chlordane	0.42	1.64	1.16	7.87	9.03

Blank spaces indicate that the OC pesticide was never detected in that phase at the site

It is somewhat misleading to consider aerial deposition upon land surfaces as a discrete source of OCs, since inputs from land-use runoff are considered for all land areas and aerial deposition is implicitly captured in those measurements. An alternate method commonly used for estimating the contribution of pollutant from atmospheric deposition is to consider only direct deposition to water. Since the surface area of all water bodies in the Central Valley watersheds is about 1% of the total area, suggesting that only a minute amount of the pounds per year shown above (about 0.40 lbs) are considered as loading to water using this method. Since OC inputs from diffuse discharges of non-point sources are determined for the 21 waterbody reaches in the Project Area, atmospheric deposition is implicitly captured in those measurements.

3.3 Pesticide Use Data

Pesticide Use Report (PUR) data from the California Department of Pesticide Regulation (DPR) provides detailed information about pesticide application rates according to crop types for each county in the state. Prior to 1990, limited use reporting requirements existed. In 1990, California began requiring full use reporting for all agricultural pesticide use and commercial pest control applications, however most OCs in this project were banned prior to this period. As outlined by DPR (DPR, 2002), DPR requires applicators to submit detailed use reports to the County Agricultural Commissioner for all “Reported Uses” with the exception of industrial, institutional, and residential landscape and garden pesticide uses. These uses are collectively referred to as “unreported uses”. PUR data contain extensive information about the quantities and types of pesticides used in each county, as well as information about the acreage and types of crops treated. These data are collected by county agriculture commissioners in most counties and then passed along to DPR for QA/QC and database management. This preliminary work contains analysis of PUR data available online and examines the years 1990-1991 with specific reference to dicofol, endosulfan and lindane as a relevant timeframe for active and residual sources of OCs (See Table 10 in Section 3.3.1 below). No pesticide sales data was examined in this document. Additional PUR data and/or sales data may be evaluated as part of the staff report source analysis.

3.3.1 Recent and Current uses of OC pesticides

Pesticide Use Report (PUR) data from the California Department of Pesticide Regulation (DPR) provides detailed information about pesticide application rates according to crop types for each county in the state. Analysis of PUR data examined 1990-1991 (only a portion of data for some crops shown here) as a relevant timeframe for potential active sources and residual sources of OC constituents such as dicofol, endosulfan and lindane (Table 16). As mentioned previously, dicofol is manufactured from a breakdown product of DDT (DDE) and contains <0.1% DDT. Endosulfan is an organochlorine pesticide that has been in current use until the recent ban (June 2010) by US EPA (US EPA, 2010). Staff is unaware how long the phasing out of endosulfan will take. Lindane is an organochlorine pesticide, persistent in the environment and is commonly referred to as gamma BHC, most use ceased about 1999 and since 2002 the only remaining agricultural uses for lindane were for seed treatments (US EPA, 2006).

Table 10. Select crops in three counties applied with Dicofol, Endosulfan and Lindane in 1991 from PUR data

	Madera (lbs of chemical applied)		
Crop	Dicofol	Endosulfan	Lindane
Beans	30	X	X
Cotton	10300	465	X
Grapes	676	X	X
Grapes (Wine)	1862	X	X
Almond	1293	X	X
	Stanislaus (lbs of chemical applied)		
	Dicofol	Endosulfan	Lindane
Beans	1744	X	212
Cotton	X	X	X
Grapes	X	4	X
Grapes (Wine)	51	49577	X
Almond	X	196	X
	Merced (lbs of chemical applied)		
	Dicofol	Endosulfan	Lindane
Beans	5376	177	X
Cotton	13139	X	X
Grapes	X	201	X
Grapes (Wine)	X	2652	X
Almond	X	240	X

X: No data reported

For the purposes of this preliminary work, staff examined pesticide use data for three counties within the Project Area. Table 10 shows substantial use of dicofol on cotton in Madera and Merced counties. Endosulfan was mainly applied to wine grapes in Stanislaus county and only Stanislaus county used lindane on beans. Staff does anticipate to conduct further analysis on PUR data that covers additional relevant counties in the project area.

3.4 Land Use Analysis

The Central Valley extends more than 400 miles from the City of Redding in the north to the Tehachapi Mountains in the south. The Project Area covers three basins, the San Joaquin River Basin, the Sacramento River Basin and where the two basins meet, the Sacramento-San-Joaquin Delta. The San Joaquin River (SJR) Basin drains approximately 2.9 million acres and includes six reaches of the San Joaquin River, the lower Tuolumne River, the lower Stanislaus River, two reaches of Orestimba Creek and the lower Merced River in the proposed BPA. The Sacramento River Basin drains the northern part of the Central Valley and covers 27,210 square miles. The Colusa Basin Drain and the lower Feather River (Lake Oroville Dam to confluence with the Sacramento River) are included in the proposed BPA. Located at the confluence of the Sacramento River and SJR, the legal boundary of the Sacramento-San Joaquin Delta comprises over 700 miles of interconnected waterways and encompasses 1,153 square miles of dyked islands and tracts. It is divided into 8 portions in the Central Valley region designated as Delta waterways including the Stockton Ship Channel. Four rivers, the Sacramento, the San Joaquin, the Mokelumne, and the Cosumnes feed the Sacramento-San Joaquin Delta.

This section describes the various existent land uses in the Project Area for the proposed BPA. Quantitative assessment of various land use categories leads to a better understanding of the relative OC pesticide contributions from different land uses in Central Valley watersheds. Three data sources were relied upon in evaluating land use categories within the project area. These included the Geographic Information Retrieval and Analysis System (GIRAS) of the USGS; the USDA National Agriculture Statistic Service (NASS) and the Watershed Analysis Risk Management Framework (WARMF) database which relies on USGS land use data generated in 2000. Comparison of land use data from these sources showed a fairly similar classification as shown in Table 11. Staff relied on the USGS land use data populated in the WARMF model because of the model's ability to represent numerous sub-catchments that drain to the impaired reaches in the Central Valley. Staff classified the land uses into six categories and these include Urban category, Native category, Agriculture (such as Cropland, Pasture, Orchard and Managed Wetlands), Rangeland/grassland category, Forest category and Open water category. The subcategories for each category are presented in Table 12.

Table 11. Comparison of three land use classification systems for Central Valley watersheds

Land Use Type	1977-1980 GIRAS (%)	2007 NASS (%)	USGS-WARMF 2000 (%)
Urban	3.78	9.14	4.05
Native*	13.87	10.87	3.61
Agriculture	59.54	52.60	56.51
Rangeland/Grassland	21.14	25.66	29.52
Forests	0.83	0.33	5.11
Open water	0.84	1.40	1.20

* Definition varies slightly among surveys and may include forests for the GIRAAS and NAAS Surveys

Table 12. Land use categories and subcategories for Central Valley Watersheds

Land Use Category	Sub-categories	% Watershed Area
Urban	Built-up areas, Residential, Industrial, Commercial, POTWs, confined feeding lots	4.05
Native	Barren, forested wetland, non-forested wetland	3.61
Agriculture	Cropland, pasture, orchards and managed wetlands	56.51
Rangeland/Grassland	Rangeland and grassland	29.52
Forests	Deciduous, coniferous and mixed forests	5.11
Open Water	Rivers, streams, open channels	1.20

With reference to land use types shown in Table 13 and Figure 6, various categories can be classified as non-point sources according to California's Management Measures for Polluted Runoff (CAMMPR, 2000). The CAMMPR defines non-point sources as contributions of diffuse loadings which include forestry (silviculture), agriculture, marinas and recreational boating, hydromodification activities, wetlands, riparian areas and vegetated treatment systems and some urban areas. In regards to the urban category this could include stormwater runoff from urban areas not encompassed by a stormwater NPDES permit. Staff does not imply that all of the listed non-point sources exist for the proposed OC BPA since further information may be available for some of these OC non-point contribution for these categories that staff feels are unlikely to be sources (e.g. marinas and recreational boating). Further details on nonpoint sources can be found at: California's nonpoint source Web site at: http://www.waterboards.ca.gov/water_issues/programs/nps/ and the USEPA's Web site at: http://www.epa.gov/OWOW/NPS/MMGI/.

Table 13. Land Use Estimates by Reach

Land Use Type (%)	SJR Mendota Pool to Bear Creek	SJR Bear Creek to Mud Sl.	SJR Mud Slough to Merced R.	SJR Merced R. to Tuolumne R.	SJR Tuolumne R. to Stanislaus	SJR Stanislaus to Delta (SJR)	Merced R. Lower (SJR)	Tuolumne R. Lower	Orestimba Creek (2 Reaches)	Lower Stanislaus R.	Colusa Basin Drain	Feather River	Delta waterways (Pooled)
Urban	1.54	0.60	1.33	2.59	4.06	5.16	0.83	7.06	1.09	5.41	5.00	9.00	8.92
Native	3.39	10.78	8.02	2.62	2.16	1.59	4.94	0.21	0.90	4.76	1.09	5.20	1.31
Agriculture	64.32	37.99	49.88	75.84	40.99	68.18	58.20	36.59	51.72	61.40	74.90	52.80	61.77
Rangeland /Grassland	28.04	49.98	38.87	18.31	36.82	13.39	30.97	37.33	42.94	19.10	19.00	30.00	19.00
Forests	1.95	0.00	0.29	0.60	15.77	11.26	4.92	18.41	3.35	8.94	0.00	1.00	0.00
Open water	0.76	0.65	1.61	0.04	0.20	0.42	0.14	0.40	0.00	0.39	0.01	2.00	9.00
Total by reach	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Figure 7 shows variation of land use in the project area between 1977 and 2007, urban land use increased by about 4% while agricultural land use decreased by 5%. This suggests that previously agricultural dominated lands were converted into urban areas which could have implications for re-emergence of previously dominant and capped OCs if construction activities occur in such areas.

3.4.1 Current Urban Land Use

Urban land use in the Central Valley watersheds occupies about 4% of the land area (Figure 6). The subcategories covered in urban land use according to the USGS-GIRAS land use classification include built-up areas, residential land, industrial and commercial lots, confined feeding lots and POTWs (Table 11). The source analysis included in the staff report may include additional information regarding acreages and percentages for each subcategory.

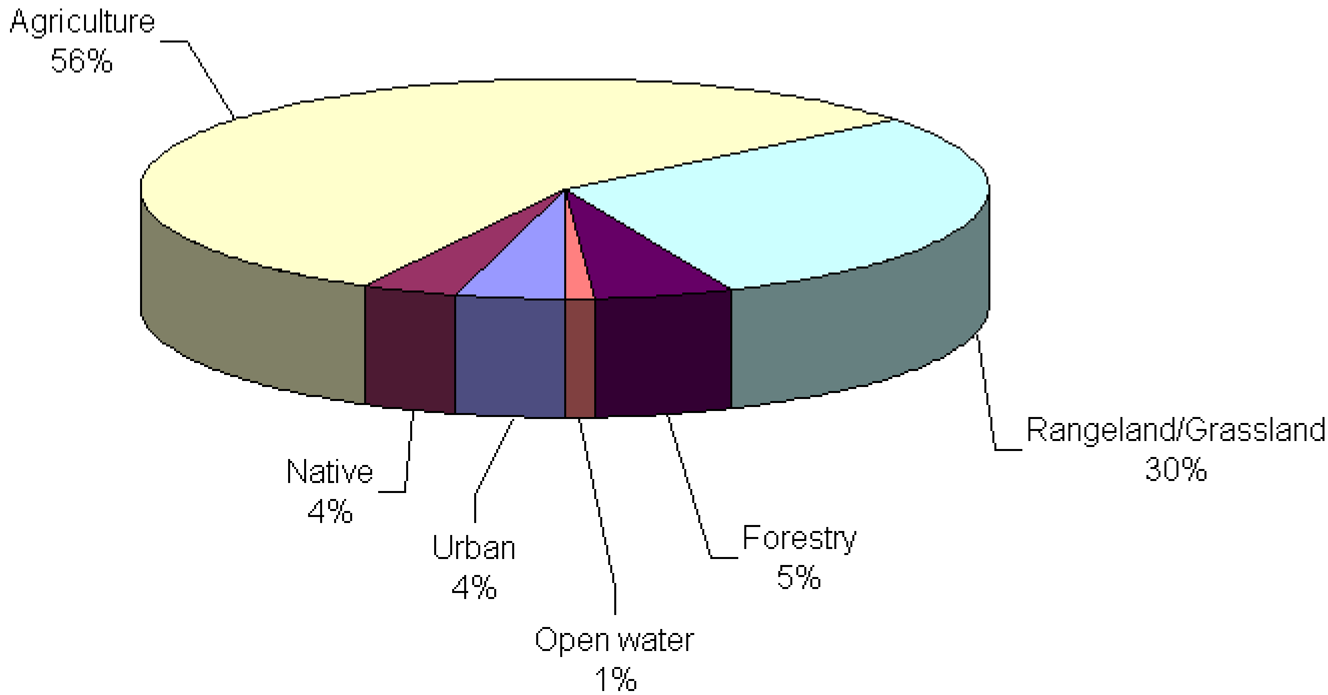

Figure 6. Percentage land use categorization for the TMDL Project Area

3.4.2 Current Agricultural Land Use

Current agricultural land use specific for each of the 21 waterbody reaches will be covered in more detail in the staff report. With regards to the Project Area, current agricultural land uses vary spatially according to such factors as climatic variations, altitude, slope, and soil type. Table 14 shows specific crop types grown in the Central Valley watersheds based on a statewide survey of irrigation methods used by growers to irrigate their crops in 2001 as conducted in California by the Department of Water Resources (DWR) (DWR, 2001). The DWR survey included a 20-crop category with irrigation methods separated into four groups: sub-surface, surface, sprinkler and drip irrigation. Staff summed the acreage covered by all four irrigation types for each crop category. The counties shown in Table 14 form part of the Project Area for the proposed BPA. The 2001 DWR survey did not have geo-referenced data and as such the data presented in Table 14 includes portions of counties not necessarily covered by the Project Area but provides a general crop acreage trend by county produced in Central Valley watersheds.

The uppermost portions of the Project Area are covered by Shasta and Tehama counties which have pasture and other deciduous trees as the main agricultural activity. Almond and Pistacio, other deciduous trees, subtropical trees and vineyard cover substantial acreage of agricultural land uses in Stanislaus, Sutter, Madera, San Joaquin and Butte counties. Corn and alfalfa are major crops in San Joaquin County while cotton is predominantly produced in Merced County. In addition, grain, pasture and tomato for processing are major agricultural outputs for Merced, Sacramento, San Joaquin, Colusa, Stanislaus and Yolo counties.

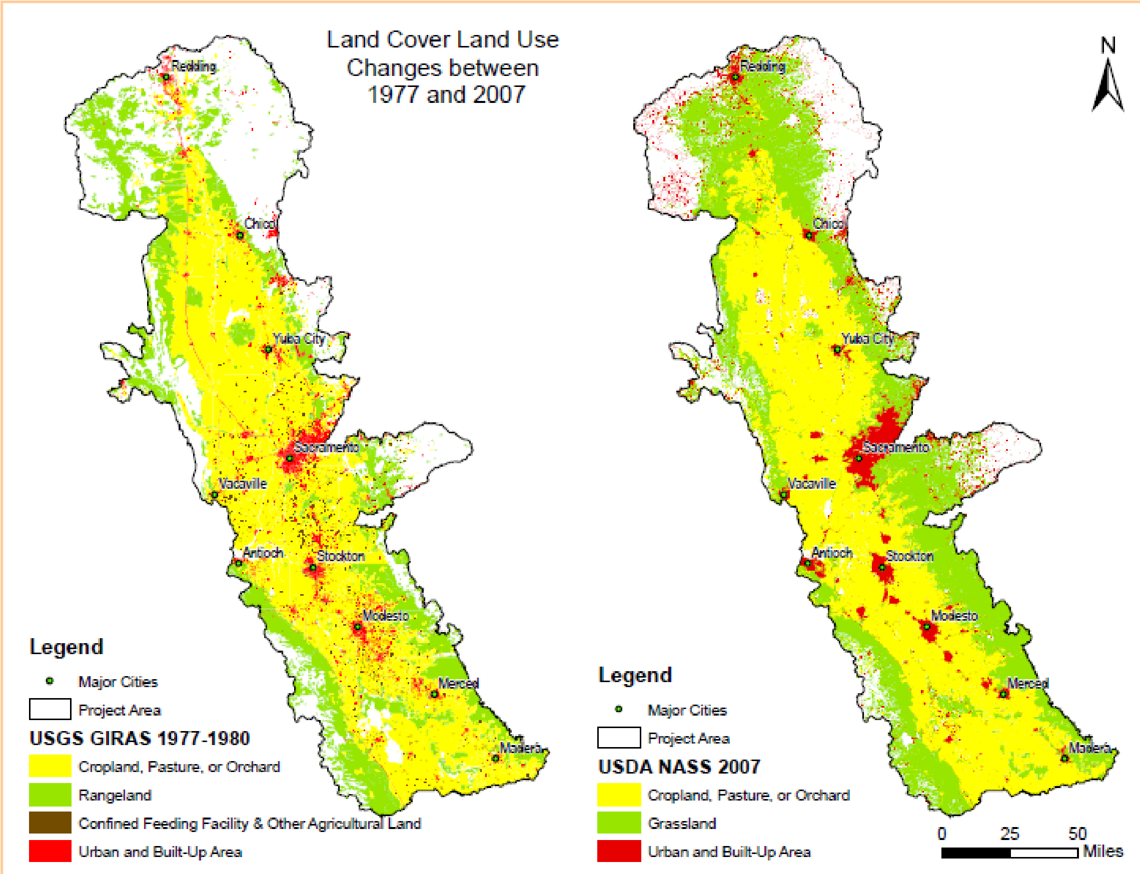

Figure 7. Land Use Changes in the Central Valley Project Area over three decades (1977 and 2007)

Agricultural activities in the watershed are somewhat challenging to characterize at a fine scale due to several factors. Staff intends to further evaluate current agricultural land use specific for each of the 21 waterbody reaches based on GIS data for the staff report. Although some changes in crop composition occur over many years (such as conversion of field crops to truck crops), there are also constant changes in crop selection from year to year as farmers adjust to fluctuating market prices or strive to preserve soil by rotating their crops/fields. Additionally, many fields are used to grow successive crops during a single calendar year. Personal communication with Jean Woods of DWR (2009) revealed that sometimes farmers use sprinkler irrigation to grow beans and then use drip irrigation to grow tomatoes on the same piece of land in succession. As such, in some portions of the Central Valley watersheds, agricultural activity is spatially heterogeneous with highly variable multi-cropping activity.

Table 14. Agricultural land use acreage in the Project Area based on DWR 2001 irrigation methods survey

Crop	Statewide	Amador	Butte	Calaveras	Colusa	Contra Costa	Glenn	Madera	Merced	Sacramento	San Joaquin	Shasta	Stanislaus	Sutter	Tehama	Tuolumne	Yolo	Yuba	Total
Corn	68940	0	40	0	0	848	3586	710	9033	4450	18464	0	4400	596	0	0	7326	0	49453
Cotton	75108	0	40	0	0	0	0	646	10626	0	0	0	0	116	0	0	0	0	11428
Dry beans	6016	0	0	0	1016	0	470	0	1612	0	376	0	330	110	0	0	0	0	3914
Grains	52904.6	0	200	0	3486	482.6	880	124	5932	1100	3638	0	5232	220	240	0	4760	0	26295
Safflower	4311.2	0	160	0	0	319.2	0	0	0	1568	1124	0	420	0	0	0	600	0	4191
Sugarbeet	3419	0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0	0	160
Other Field crops	15386	0	40	0	0	0	496	64	189	56	330	0	1020	0	70	0	2398	0	4663
Alfalfa	137843	0	60	0	3430	221	572	422	23224	1812	5870	90	7064	440	0	0	6118	100	49423
Pasture	63677.9	202	1130	96	10	282	1715	166	1334	2802	4207	1714	6058	490	1306	80	110	1308	23010
Cucurbit	1962.59	0	20	0	300	14	34	2.34	0	0	10	0	302	0	0	0	0	0	682
Onion&Garlic	4069.84	0	0	0.5	56	4	0	2.34	0	0	120	0	0	0	0	0	43	0	226
Potato	6080.59	0	0	0	0	0	0	2.34	455	0	1460	0	80	0	0	0	0	0	1997
Tomato (fresh)	13540.6	0	0	1.13	30	123	0	0	780	52	1484	0	1600	0	0	0	10	0	4080
Tomato (process)	15226	0	0	0	0	0	0	0	964	400	2322	0	1712	0	0	0	5210	0	10608
Other Truck Crops	69904.7	0	0	4.5	0	69	0	0	168	284	1148	0	720	0	0	0	56	0	2450
Almond & Pistacio	159569	0	4749	1	4045	171.2	9972	29367	18077	0	5220	2.5	11462	210	1630	0	252	60	85219
Other Deciduous trees	74543.5	0	4056	0	991	136	4146	7188	4054	1068	9165	17.5	4906	3963	4233	0	3408	1272	48605
Subtropical Trees	79326.1	0	1364	0	0	0	1149	16588	236	20	39.8	231	56	0	421	30	148	200	20483
Turfgrass & landscape	1964.28	0	2	4	0	0	0	0	4	0	0	10	0	0	0	0	0	0	20
Vineyard	160955	1259	168.4	173	80	256.6	0	8695	356	2760	30669	0	2592	0	0	0	1768	0	48777
Total	1014748	1461	12030	280	13444	2927	23020	63977	77204	16372	85647	2065	47954	6145	7900	110	32207	2940	395683

3.5. Historical Assessment of OC constituents

This section presents information about the history of use for some OC constituents based upon a review of the literature and all other available information. Similar information for the other OC constituents included in the OC BPA will be discussed in the Staff Report. Given the highly persistent nature of OCs, such information is useful in assessing the sources of these chemicals. Historical uses are described according to local spatial scales whenever possible, although such detailed information is not available in many cases.

3.5.1 DDT

DDT (dichlorodiphenyltrichloroethane) was first synthesized in 1874, and its insecticidal properties were discovered in 1939 by Paul Hermann Müller (Stapleton, 1998, ATSDR, 2000a). It was widely used to control insects in agriculture and insects that carry diseases such as malaria. The U.S. military began using DDT extensively for control of malaria, typhus, and other insect-transmitted diseases in 1944, particularly in the Pacific, where much of the action of World War II (1939-1945) took place in highly malarious areas (Díaz-Barriga et al. 2000).

At its peak in 1962, DDT was used on 334 agricultural commodities. It was also used in homes as a mothproofing agent and to control lice. In 1972, 67–90% of the total US consumption of DDT was on cotton; the remainder was primarily used on peanuts and soybeans. The uses of DDT in California ranged from control of agricultural pests to control of cockroaches in residences and mosquito abatement in neighborhoods. During the early 1970s, the US Food and Drug Administration (USFDA) began rejecting the importation of commodities due to high residue levels, especially of DDT. Table 15 shows statewide reported DDT usage in California for the years 1970-1980. All uses of DDT have been banned in the USA since 1972, except for control of emergency public health problems (ATSDR, 2002).

In August of 1984, a Resolution (House Resolution [HR] 53) passed by the California Legislature, directed the California Department of Food and Agriculture (CDFA) to investigate possible sources of DDT in the environment and to report findings to the Legislature within one year. The pesticide programs of CDFA were transferred in 1991 to the Department of Pesticide Regulation (DPR). HR 53 was introduced in response to studies showing DDT residues were found in California water, fish, shellfish, and produce samples despite the banning of DDT use in 1972. Additionally, the chemical composition of the DDTr (CDFA used ‘r’ to indicate that it includes isomers) being found indicated that it might be from recent use. CDFA investigated three possible sources of contamination by DDT and/or its breakdown products: illegal use of DDT, use of other pesticides that might be contaminated with DDTr, and long-lived residues from previous legal applications of DDT. Based on analysis of historical and empirical evidence, CDFA concluded that residues from legal applications of DDT, before its use was banned, appear to be the source of this contamination (Mischke et al, 1985).

As part of the Mischke et al, 1985 Report, CDFA also conducted a soil monitoring study in 1985 in 32 counties where DDT was historically used. Soil concentrations ranged from zero to thousands of parts per billion (ppb) of DDT or its degradation products. Staff selected data from some of the sampled counties covered in the Project Area (Figure 8). Data for the selected counties revealed DDTr ranges from 0.5 to 465 ppb (Figure 8). The report also described CDFA activities to ensure pesticide product quality, monitor for pesticide residues on fresh fruits and vegetables, and monitoring the activities of all persons selling, applying and storing pesticides.

Specific findings of the Mischke et al, 1985 Report are quoted below:

1. “Before its ban, DDT was widely used in California in agriculture and for control of mosquitoes and other disease-carrying insects.
2. There was no evidence of any illegal use of DDT since its ban. In 1983, 87,000 pesticide use enforcement inspections and 3,501 investigations of possible violations were made by California County Agricultural Commissioners. None of these involved DDT. Also in 1983, about 1300 pesticide samples were analyzed to determine what chemicals they actually contained. The results show 97.5% of these samples met registration and labeling requirements. The remaining 2.5% did not involve DDT. Even before its ban, agricultural use of DDT was declining as more insects became resistant to DDT.
3. Contamination of other pesticides by DDT could not account for the residues. There have been reports that dicofol (Kelthane®) contained large amounts of DDT. Samples of dicofol sold in California examined in 1983-84 contained very low levels of DDT, usually less than 1%, too low to account for DDT residues found.
4. Detectable levels of DDT found on some California produce were, in most cases, well below acceptable levels. Nearly all produce samples found with residues of DDTr have an edible portion which grows in or close to the ground, such as carrots, beets, lettuce, or spinach. DDTr residues found on produce are probably the result of contamination from soil containing DDTr.
5. On average, about half the DDTr detected was present as DDT in the environment. However, the composition of DDT found in soil was more stable than previously thought; therefore the kinds of DDT residues present in soil did not necessarily indicate new use.
6. Soil contaminated with DDTr may be moved into drains as a result of normal field work such as land leveling. Fish and shellfish pick up DDTr from the soil particles in the water.
7. DDTr residues were present in soil wherever DDT was used legally in the past. In 1985, CDFA collected 99 soil samples in 32 California counties from locations where DDT had been used in the past. All samples contained DDTr”.

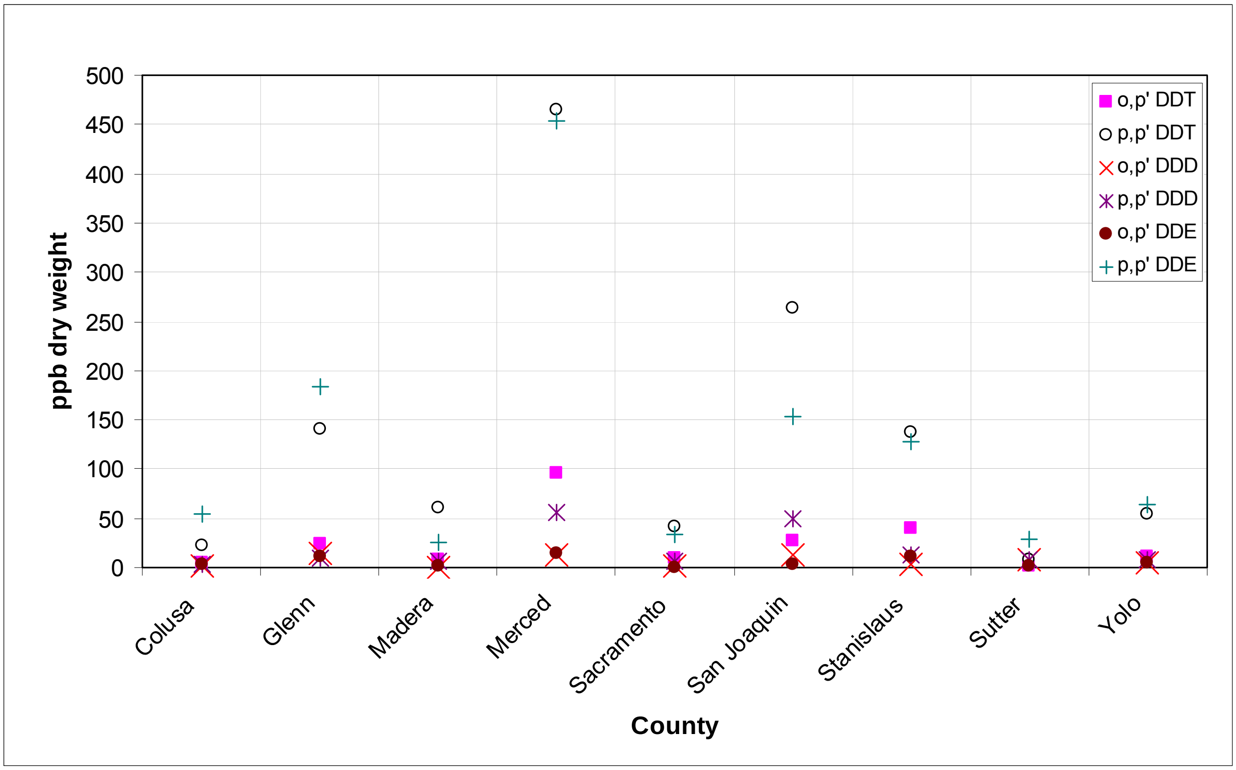

Figure 8. 1985 Soil Monitoring Survey for DDTr (Average Concentration for Selected Counties)

3.5.1.1 Historical Agricultural land use

In California, DDT uses included agricultural and urban pest control (See Table 15; Mischke et al., 1985). Specific uses and application rates in the Central Valley Watersheds remains unclear and is not known to Staff. There is limited literature that documents historical agricultural land use of OC pesticides in California. The State Water Control Board conducted a study in 1984 (Agee, 1986) entitled “DDT in the Salinas Valley” to investigate the source of high levels of DDT in the Blanco Drain located in Monterey County. Concentrations of total DDT residues in the Blanco Drain study ranged from 145 ppb to 3,984 ppb. Soils adjacent to the Drain contained concentrations ranging from 1,067 ppb to 2,888 ppb. The report concluded that the source of DDT in the drain was erosion from adjacent fields and the practice of plowing soil from adjacent fields into Blanco Drain, although other erosion events also may have contributed to the DDT found in the Drain.

Table 15. DDT Use in California from 1970 to 1980a (Mischke et al, 1985)		
Year	**Pounds Used**	**Main Use**
1970	1,164,699	agricultural
1971	111,058	agricultural
1972	80,800	agricultural
1973b	No use reported	--
1974	160	Residential pest control (special local need)
1975-1980	<200 lbs per year	Vector control (special local need)
a. 1970 was the first year in which the amount of restricted pesticides used in California was reported. In 1980, the introduction of new pesticides replaced the need to use DDT for vector control.		
b. Year all use banned except for special local needs (SLN)		

3.5.1.2 Historical Urban use

In many areas throughout the United States and globally, the primary non-agricultural use of DDT was for mosquito control and other disease-carrying insects. Mischke et al., 1985 report that uses of DDT in California included control of cockroaches in residences and mosquito abatement in neighborhoods some of which were urban (Table 15). According to California Agriculture 1965, increasingly strict city and county ordinances caused dairy farmers and poultry ranchers in Central Valley watersheds to intensively use OC insecticides. For many years before it was banned, DDT was commonly used by private residents for a variety of home and garden uses. However, there are no known records of such residential uses of DDT for the Project Area. The use of DDT was banned in 1972 but some uses of DDT continued under the public health exemption, for example, in June 1979, the California Department of Health Services was permitted to use DDT to suppress flea vectors of bubonic plague in both non-urban and urban areas (Bate, 2007).

3.5.1.3 POTWs

Imported produce and clothing of agricultural workers from other countries may contribute DDT pesticides to influent received by POTWs in the Central Valley watersheds. Due to widespread past use of DDT and the persistence and slow degradation of its breakdown products, low levels of DDE residues are still detected frequently in foods consumed in the US (Snedeker, 2001 and EIP, 1997). Studies document that persistent OCs pesticides are pervasive in the U.S. food supply. Most of these OC pesticides were targeted for global elimination under the international persistent organic pollutants (POPs) treaty that was signed in May 2001 in Stockholm but were banned in the United States several years ago. Nevertheless, these POPs including DDT continue to make their way into the food supply from sources outside of U.S. agriculture.

These pesticide residues are found in produce imported from countries where the pesticides are still in use or were recently banned (Groth, 1999). However, there is no clear evidence, that imported produce has more OC pesticide residues than fruits and vegetables grown in the United States. In the case of winter squash, for example, dieldrin was found in 35 percent of the domestically produced samples, and found in only 4.2 percent of the samples from Mexico. Moreover, the residue levels were significantly higher in the U.S. squash (Schafer et al., 2001).

In the case of carrots, in contrast, DDT was found in 75 percent of Canadian samples taken, but only found in 6.4 percent of the U.S.-grown carrots tested. While the data on imported OC pesticide residues collected through USDA's pesticide data program is not comprehensive, the samples collected clearly illustrate that contamination levels depend on a range of variables. U.S. consumers cannot assume that domestically produced fruits and vegetables are less contaminated with OC pesticides than imported produce (Groth et al. 1999; Schafer et al., 2001). The residues associated with produce consumed by the population may contribute OCs to influent received by POTWs in the Central Valley watersheds.

3.5.1.4 Potential OC input from Dicofol

Dicofol is manufactured through chlorination of dichlorodiphenyldichloroethylene (DDE, one of the breakdown products of DDT), and contains very small amounts (<0.1% since 1985) of total DDT (DDT+DDE+DDD). As an example, data from the California Department of Pesticide Regulation was analyzed for 11 counties (DPR, 2008) (Table 16) that are within the project area. Use of dicofol was extremely limited in most counties. Results in Table 16 indicate that over the six years, the total pounds of dicofol active ingredient (0.1% DDT) applied in the 11 counties was about 300 lbs. The Project Area covers an expanse of about 8,519,571 hectares, this results in application of about 0.000006 lbs/ha per year of DDT. Dicofol is not considered as a significant source (Mitschke et al.,1985; DPR, 2008) of OC pesticides. Because dicofol contains only very small amounts of DDT and because its use has declined dramatically (Table 16), dicofol is considered to be a possibly inconsequential continuing source of DDT in the Central Valley watershed.

Table 16. Annual Dicofol Use in Select Counties within Project Area during the Years of 2001-2006 (Pounds of Active Ingredient)

County/Year	2001	2002	2003	2004	2005	2006	Total by County
Merced	19746	17070	18552	27707	19666	22032	124773
Stanislaus	14536	13948	11925	13822	7120	5330	66681
San Joaquin	3379	4895	3527	5582	4839	5924	28146
Butte	4846	1278	4196	2255	3797	1102	17474
Sutter	3071	4067	2500	1846	1580	2905	15969
Yolo	1511	2466	1771	403	431	341	6924
Colusa	233	770	403	1775	756	479	4415
Madera	4369	3019	2037	2454	5358	4938	22173
Glenn	1066	1273	980	618	1226	1170	6333
Tehama	1128	2356	2159	42	277	29	5991
Contra Costa	1282	33	301	334		10	1960
Total by year	55167	51175	48351	56838	45050	44260	
Statewide use	212809	183014	186112	216836	193791	101501	1094061

3.5.2 Chlordane

Chlordane is a pesticide that was first used in 1948 for crops such as corn and citrus, home lawns and gardens, and termite control. In 1978, the U.S. EPA cancelled the use of chlordane on all food crops and for applications to lawns and gardens, although it was still registered for use in termite control. In 1988, the U.S. EPA cancelled all uses for chlordane (ATSDR, 1994).

The use pattern of chlordane in the US during the mid 1970s was as follows: 35% by pest control operators, mostly for termite control; 28% on agricultural crops, including corn and citrus; 30% for home lawn and garden use; and 7% on turf and ornamentals. The use of chlordane decreased noticeably in the 1970s when EPA moved to cancel all uses other than subterranean termite control. Chlordane does not degrade rapidly in soils and may persist in soil for over 20 years (ATSDR, 1994). Thus, soils historically treated with chlordane can continue to be a present source of chlordane in the environment; these contaminated soils may be transported to waterbodies via runoff causing water quality impairments. Moreover, chlordane will bioaccumulate in the fat tissue of exposed organisms and is considered highly toxic to fish and freshwater invertebrates (NPTN Chlordane Fact Sheet, 2001, EXTOXNET Chlordane, 1996). In combination with consulting other sources and PUR data, Staff continues to investigate specific uses of chlordane in Central Valley watersheds.

3.5.3 Dieldrin/Aldrin

Source analysis for dieldrin and aldrin is discussed here together since aldrin rapidly degrades to dieldrin in the environment (ATSDR, 2002b). Dieldrin and aldrin were used extensively from the 1950s until 1970 as a structural pesticide for the control of termites (ATSDR, 2002b) and as an agricultural pesticide for cotton, corn, and citrus crops. The agricultural use of dieldrin was banned by the US Department of Agriculture in 1970 and in 1987 all uses of dieldrin were cancelled (ATSDR, 2002b).

Use of dieldrin and aldrin in the US peaked in 1966. Decreased use after that time is attributed primarily to increased insect resistance, and development of more effective and environmentally safer pesticides (ATSDR, 2002b). Dieldrin and aldrin ranked second after DDT among agricultural chemicals used in the United States in the 1960s. Aldrin use was most concentrated in the midwest, while dieldrin was used more heavily in the south and on the west coast. Dieldrin was recommended for use on approximately 90 crops, principally corn, hay, wheat, rye, barley and oats, and orchards and vegetables. Dieldrin is a persistent compound in the environment that easily binds to soil and is often conveyed to surface waterbodies in runoff. In combination with consulting other sources and PUR data, Staff continues to investigate specific uses of dieldrin in Central Valley watersheds.

3.5.4 Toxaphene

Toxaphene is an insecticide containing over 670 chemicals that was first used in the 1940s. EPA canceled the registrations of toxaphene for most uses as a pesticide or pesticide ingredient in 1982. Toxaphene was one of the most heavily used insecticides in the United States until that time. It was used primarily in the southern United States to control insect pests on cotton and other crops. Toxaphene was also used to control insect pests on livestock and to kill unwanted fish in lakes (ATSDR, 1996). All registered uses were banned in 1990 and existing stocks were not allowed to be sold or used in the United States.

After the 1969 DDT ban, toxaphene became the most heavily used insecticide in the United States. In 1974, an estimated 44 million pounds of toxaphene used on crops in the US was distributed as follows: 85% on cotton, 7% on livestock and poultry, 5% on other field crops, 3% on soybeans, and less than 1% on sorghum (ATSDR, 1996). In combination with consulting other sources and PUR data, Staff continues to investigate specific uses of chlordane in Central Valley watersheds.

3.6 Ground water

The Annual Well Inventory Report “Sampling for Pesticide Residues in California Well Water: 1997 Update to the Well Inventory Database” (DPR, 1998) revealed presence of OCs in groundwater from wells in Sacramento, Stanislaus, San Joaquin, Sutter and Merced county. The DPR Reports contributed to the well inventory database developed by DPR whose purposes to develop a database with centralized information on the occurrence of nonpoint source contamination of ground water by the agricultural use of pesticides and to facilitate graphical, numerical, and spatial analyses of the data.

The DPR Reports notes that Merced county had Endrin, Endosulfan, DDT, Dicofol and Dieldrin around the Merced Municipal airport while Stanislaus county had BHC and DDT around the Chemagric agricultural Chemicals. For Chemagric Agricultural Chemicals and is reportedly under ongoing monitoring. There was a Cleanup and Abatement Order issued in late 1993 but the area with elevated BHC concentrations was discovered in 1994. The DPR Reports do not quantify groundwater discharges into surface waters within the watersheds. The DPR Reports states there was consideration for soil excavation and ground water extraction and treatment. For most of the sites at the aforementioned counties, it is reported that there is ongoing groundwater assessment and that soil removal actions had occurred with more planned, which reduce the likelihood that the significant amounts of OCs from these sources would move through groundwater into surface waterbodies addressed in this project area.

3.7 Open Space, channel erosion and stream bed contribution

Both open space (if OCs were applied in the past) and channel erosion may contribute sediment to surface waters and may serve as potential sources of OCs. As shown in Figure 9, inputs to the water column include loads from land uses shown in Table 13, resuspension of sorbed OCs from sediment, and diffusion of dissolved OCs from sediment. Potential losses are from volatilization, degradation, outflow or sediment burial below the active layer. Activities that effect the transportation and deposition of sediment may contribute to OC loading, such as water management and storage, dredging and dredge materials disposal and reuse and management of flood conveyance activities.

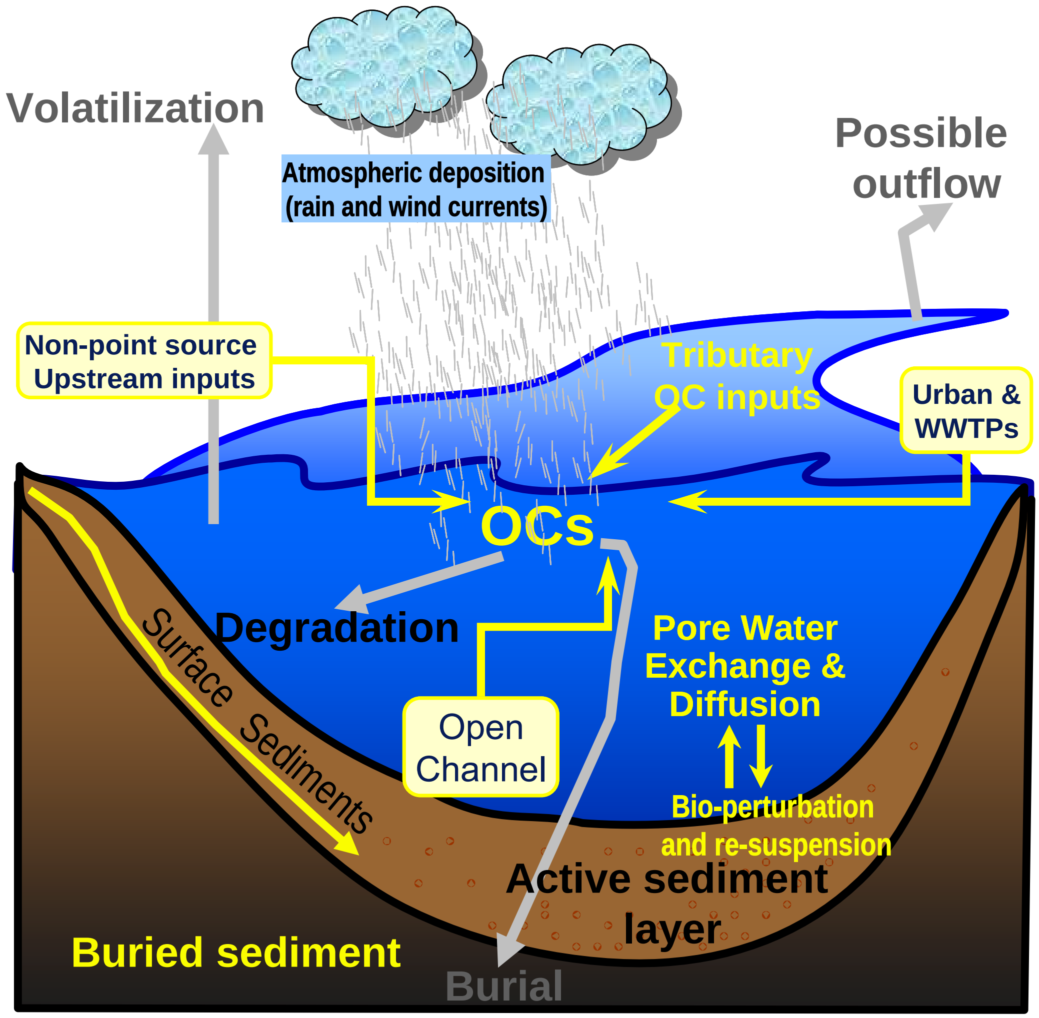

Figure 9. Illustration for OC fate in open channel and streambed showing processes for input (yellow arrows) and losses (grey arrows)

3.7.1 Estimation of open channel and streambed sediment loads

As presented in the current conditions assessment, Section 2.3 (Water, Sediment and Fish Tissue Data), the sediments in the Central Valley waterbodies addressed in the proposed BPA are contaminated with OC pesticides. This section estimates the mass of active OC pesticides residing in the sediments of these Central Valley waterbodies. Subsurface sediment properties are important in assessing how sediments contribute pollutants to the waterbodies. It is theorized that the sediments in Central Valley waterbodies form two layers. The top layer is composed of loose silty organic material that is easily resuspended; the top layer can be considered the active layer of sediment. In modeling the fate of PCB contaminants in sediment (which can be used to represent

OC constituents because of close proximity with similar characteristics to a portion of the OC BPA Project Area), Davis 2004 estimated that the depth of active sediment layer (ASL) to be about 0.15 m. This estimation is based on average depth of bioturbation and storm-driven resuspension (Davis, 2004). This evaluation represents the best information available to Staff on the depth of active sediments for Central Valley waterbodies. The lower layer of sediment is firm sediment that is deeply buried below the active layer and not likely to actively contribute pollutants to Central Valley rivers and streams. The source assessment is based on an estimate of the volume of the active layer of sediment as a source of OC contaminants.

Staff relied on GIS layers developed by Central Valley Water Board staff during the compilation of the 2006 303(d) list for OC impaired waterbodies as a reference. Staff needed to estimate the surface area for each of the OC impaired waterbodies in order to calculate OC load factors in open channels. Due to insufficient surface area data, staff used the GIS layers for DWR Land Use Surveys (DWR, 2000) as a tool to estimate the surface area for the OC impaired waterbodies for counties in the Central Valley within the Project Area. Staff isolated areas that are designated as open water in the DWR Land Use Survey by overlaying of the 2006 303(d) layer of OC impaired waterbodies as a reference. Staff identified the corresponding waterbodies and tallied the total areas designated as water for each OC impaired waterbody.

Some complications hindered staff from obtaining accurate area estimates. First, sections of waterbodies representing rivers were interrupted by areas with land uses designated as riparian vegetation and native vegetation despite the presence of free-flowing rivers. Second, some sections of waterbodies representing various rivers were merged together at their confluence. To resolve these complications, staff divided each impaired waterbody down to smaller sections for easier estimation. For each section, staff used the closest match area (in terms of proximity and of width) designated as water by the DWR Land Use Survey (DWR, 2000) to compute a representative average width, which was multiplied by the section length to yield a surface area estimate.

Staff relied on the ArcGIS 9 measurement tool for finding the length of sections and the GIS identifier tool for finding the area of polygons. The GIS measurement tool yields rough estimates with potential errors especially when measuring meandering line features. Consequently, the surface areas are coarse estimates (~±5%) based on the afore-mentioned constraints. Staff multiplied the greatest active sediment depth (0.15 m) by the surface area of the corresponding rivers and waterbodies within the Project Area to estimate the volume of contaminated sediments.

Equation (8):
Volume Sediment = Depth Active Sediment x Stream Surface Area

The volume of sediment was then multiplied by the observed pollutant concentration (from monitoring data) to estimate the mass of pollutants residing in the active waterbody sediments.

Equation (9):
Existing Sediment Pollutant Load = Volume Sediment x Observed Pollutant Conc.

Assumptions made in computations:

1. As evidenced from Figure 5, the open water surface has a different area to the area of the active sediment in the channel owing to variation in geometry with depth. Staff assumed that the top area of the stream equates to the area of sediment (potentially over-estimates area).
2. Assumed that the buried sediment does contribute to the re-suspension of sediment.
3. Assumed that the depth of active layer derived from Davis, 2004 sediment studies was representative of Central Valley watersheds. The depth of active layer was based on average depth of bioturbation and storm driven re-suspension

Table 17 presents values for parameters used in this analysis and the existing pollutant loads. Conversion factors are not included in the table. On the overall the estimated total streambed load of OC constituents in the active sediment layer are about 138 kg (about 304 lbs).

Table 17: Parameter values used for streambed sediment source analysis estimation						
Applicable Waterbodies in Project Area	**OC Constituent**	**Average Sediment conc. (µg/kg)***	**Open water area (m^2)**	**Depth of active sed. (m)**	**Particle Density (g/ml)****	**Estimated Existing Load (g)**
San Joaquin River (Mendota pool to Bear Creek)	DDT	1	4088298.1	0.15	1.1	674.56919
	Group A Pesticides	1	4088298.1	0.15	1.1	674.56919
San Joaquin River (Bear Creek to Mud Slough)	DDT	1.33	804322.59	0.15	1.1	176.50859
	Group A Pesticides	1	804322.59	0.15	1.1	132.71323
San Joaquin River (Mud Slough to Merced R.)	DDT	1.5	978578.69	0.15	1.1	242.19823
	Group A Pesticides	1	978578.69	0.15	1.1	161.46548
San Joaquin River (Merced R. to Tuolumne R.)	DDT	1.4	3694823.5	0.15	1.1	853.50424
	Group A Pesticides	1	3694823.5	0.15	1.1	609.64589
San Joaquin River (Tuolumne R. to Stanislaus R)	DDT	1.5	1169186.9	0.15	1.1	289.37377
	Group A Pesticides	1	1169186.9	0.15	1.1	192.91584
San Joaquin River (Stanislaus R. to Delta Boundary)	DDT	1.4	360483.93	0.15	1.1	83.271787
	Group A Pesticides	1	360483.93	0.15	1.1	59.479848
	Toxaphene	1	360483.93	0.15	1.1	59.479848
Tuolumne River, Lower (Don Pedro Reservoir to San Joaquin River)	Group A Pesticides	4	6695525.6	0.15	1.1	4419.0469
Stanislaus River, Lower	Group A Pesticides	2	5613778.4	0.15	1.1	1852.5469
Orestimba Creek (Below Kilburn Road)	DDE	1.5	246809.52	0.15	1.1	61.085357
Orestimba Creek (Above Kilburn Road)	DDE	1.5	600782.85	0.15	1.1	148.69376
Merced River, Lower (McSwain Reservoir to San Joaquin River)	Group A Pesticides	1	11396677	0.15	1.1	1880.4516
Feather River, Lower (Oroville Dam to confluence with Sacramento River)	Group A Pesticides	1.1	14688263	0.15	1.1	2665.9198
Colusa Basin Drain	Group A Pesticides	17.7	3269860	0.15	1.1	9549.6261
Delta Waterways (Stockton Ship Channel)	DDT	2	6487110.8	0.15	1.1	2140.7466
	Group A Pesticides	1.2	6487110.8	0.15	1.1	1284.4479
Delta Waterways (Eastern portion)	DDT	3.882	11298823	0.15	1.1	7237.2352
	Group A Pesticides	1.38	11298823	0.15	1.1	2572.742
Delta Waterways (Western portion)	DDT	2.23	58776543	0.15	1.1	21626.829
	Group A Pesticides	1.1	58776543	0.15	1.1	10667.942
Delta Waterways (Southern portion)	DDT	3.17	12646426	0.15	1.1	6614.7133
	Group A Pesticides	1.1	12646426	0.15	1.1	2295.3264
Delta Waterways (Northern portion)	DDT	3.6675	27498389	0.15	1.1	16640.307
	Group A Pesticides	1.3	27498389	0.15	1.1	5898.4045
Delta Waterways (Central portion)	DDT	2.23	46235335	0.15	1.1	17012.291
	Group A Pesticides	1.1	46235335	0.15	1.1	8391.7132
Delta Waterways (Export area)	DDT	2.3	2359317.3	0.15	1.1	895.36091
	Group A Pesticides	1.3	2359317.3	0.15	1.1	506.07356
Delta Waterways (Northwestern portion)	DDT	4.146	10469218	0.15	1.1	7161.887
	Group A Pesticides	1.3	10469218	0.15	1.1	2245.6472

* Average concentration for data collected between 2004 and 2008.
** Density of suspended solids (g ml^{-1}) (After Krank and Milligan 1992; Davis, 2004)

3.8 NPDES Facilities in the Central Valley

OC's continue to be detected in NPDES discharges, such as POTWs, in the Central Valley waterbodies. The source for these OCs may vary, as it possible for some POTWS to have some stormwater entering into their systems, as well as possible OC contributions from imported produce and clothing of agricultural workers from other countries. Also, due to the widespread past use of OCs, their persistence and slow degradation of breakdown products, low levels of constituents such as DDE residues are still detected frequently in foods consumed in the U.S. (Snedeker, 2001 and EIP, 1997).

A preliminary list of NPDES facilities in the project area are provided in Tables 18, 19 and 20. This section provides a summary of TMDL staff efforts to identify NPDES facilities in the Central Valley within the project area. Some of these facilities include municipal and industrial dischargers which include municipal wastewater treatment plants (WWTPs). WWTPs are also referred to as POTWs in some parts of this attachment. An example of stormwater discharges include Municipal Separate Storm Sewer Systems (MS4). There are other minor point source discharges such as domestic use of supply water, food processors, fish rearing hatcheries, worm culturing, cooling plants, and groundwater remediation facilities. Information about contributions of each NPDES facility relative to the impaired reach it drains to has been provided. As shown in Tables 18, 19, and 20, depending on the location of a NPDES facility in the watershed, it could drain or contribute OC loadings to numerous impaired reaches.

Some of the information provided in Tables 18, 19, 20 was obtained from final Staff Report on the review of Methylmercury and Total Mercury Discharges from NPDES Facilities in California's Central Valley (Central Valley Water Board, 2010).

3.8.1 NPDES Facilities in the San Joaquin River Basin

To date, staff have complied twenty NPDES facilities in the Lower SJR Basin Project Area as presented in Table 18. The Lower SJR Basin Project area encompasses some of the waterbodies previously listed in Table 17 which include six reaches of the San Joaquin River, forming a length of about 130 miles of the lower SJR, from the Mendota Dam to the Airport Way Bridge near Vernalis. The reaches are SJR (Mendota Pool to Bear Creek), SJR (Bear Creek to Mud Slough), SJR (Mud Slough to Merced R.), SJR (Merced R. to Tuolumne R.), SJR (Tuolumne R. to Stanislaus R) and SJR (Stanislaus R. to Delta Boundary). Also included in the proposed BPA are smaller watersheds within the SJR Basin including the watersheds of the lower Tuolumne River (Don Pedro Reservoir to SJR), Orestimba Creek (Below Kilburn Road), Orestimba Creek (Above Kilburn Road), Lower Merced River, (McSwain Reservoir to SJR) and Lower Stanislaus River.

Table 18 shows the NPDES Permit number, facility name and type, the county location, and the project areas for specific waterbody pollutant combinations (reaches) the facility is located in and which impaired reaches the facility contributes to. For the lower SJR Basin, the Water Quality Control Plan for the Sacramento River and San Joaquin River

Basins (Basin Plan, 2009), contains defined sub areas found on pages I-1.00 through I-4.00. There are seven major sub areas in the LSJR watershed, some of which are further subdivided into minor subareas (Basin Plan, 2009).

Table 18. Preliminary List of NPDES Facilities in the San Joaquin River Basin Project Area

NPDES #	Facility	Facility Type	County	Project Area Location	Contributor to Impaired Reach
Municipal Wastewater Treatment Plants					
CA0079219	Merced WWTP	Municipal WWTP	Merced	LSJR upstream of Salt Slough, Bear Creek	SJ2, SJ3, SJ4, SJ5, SJ6, SJ8,DWW2, DWW4
CA0079197	Atwater WWTP	Municipal WWTP	Merced	LSJR upstream of Salt Slough, Bear Creek	SJ2, SJ3, SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
X	Gustine WWTP	Municipal WWTP	Merced	LSJR upstream of Salt Slough, Grassland	SJ3, SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
CA0079103	Modesto WWTP	Municipal WWTP	Stanislaus	East Valley Floor, SJR (Merced R. to Tuolumne R.)	SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
CA0078950	Planada WWTP	Municipal WWTP	Merced	LSJR upstream of Salt Slough, Bear Creek	SJ2, SJ3, SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
CA0078948	Turlock WWTP	Municipal WWTP	Stanislaus	East Valley Floor, SJR (Merced R. to Tuolumne R.)	SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
X	Newman WWTP	Municipal WWTP	Stanislaus	East Valley Floor, SJR (Mud Slough to Merced R.)	SJ3, SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
X	Patterson WWTP	Municipal WWTP	Stanislaus	Westside Creeks, SJR (Merced R. to Tuolumne R.)	SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
	Minor Point Sources				
CA0081752	Calaveras Trout Farm Inc (Hatchery)	Aquaculture	Merced	Merced River, Lower Merced R.	SJ4, SJ5, SJ11, DWW2, DWW4
CA0080055	Department of Fish and Game Merced River Fish Hatchery	Aquaculture	Merced	Merced River, Lower Merced R.	SJ4, SJ5, SJ11, DWW2, DWW4
CA0083801	Modesto ID Regional WTP	Drinking Water Treatment	Stanislaus	Tuolumne River, Lower Tuolumne R.	SJ4, SJ5, SJ7, SJ8, DWW2, DWW4
CA0082082	CA Dairies Inc Los Banos Foods	Food Processing	Merced	Grassland, Grassland	SJ2,SJ3, DWW2, DWW4
CA0004146	Hershey Chocolate USA Oakdale Plant	Food Processing	Stanislaus	Stanislaus River, Lower Stanislaus R.	SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
CA0083895	Former Baltimore Aircoil Company	Groundwater Remediation	Madera	LSJR upstream of Salt Slough, Fresno Chowchilla	SJ1, SJ2, SJ3, SJ4, SJ5, SJ8, DWW2, DWW4
97-003	Stanislaus Farm Supply	Groundwater Remediation	Merced	LSJR upstream of Salt Slough, Bear Creek	SJ3, SJ4, SJ5, SJ8, DWW2, DWW4
CA0081833	General Electric Company Groundwater Cleanup System	Groundwater Remediation	Merced	LSJR upstream of Salt Slough, Bear Creek	SJ2, SJ3, SJ4, SJ5, SJ8, DWW2, DWW4
X	Western Farm Service	Groundwater Remediation	Merced	LSJR upstream of Salt Slough, Bear Creek	SJ2, SJ3, SJ4, SJ5, SJ6, SJ8, DWW2, DWW4
X	Jim and Jeffery Flowers, Flowers' Worm Farm	Worm Culture	Stanislaus	East Valley Floor, Lower Stanislaus R.	SJ4, SJ5, SJ8, DWW2, DWW4
Stormwater Permittees					
CAS083526	Modesto	MS4	Stanislaus	East Valley Floor, Lower Stanislaus R.	SJ6, SJ8, DWW2, DWW4
CA 0083330	US Army Riverbank Army Ammunition Plant	DWR	Stanislaus	Stanislaus River, Lower Stanislaus R.	SJ6, SJ8, DWW2, DWW4

Contributor to Impaired Reach Codes

San Joaquin River (Mendota pool to Bear Creek)	SJ1
San Joaquin River (Bear Creek to Mud Slough)	SJ2
San Joaquin River (Mud Slough to Merced R.)	SJ3
San Joaquin River (Merced R. to Tuolumne R.)	SJ4

Table 18. Preliminary List of NPDES Facilities in the San Joaquin River Basin Project Area

NPDES #	Facility	Facility Type	County	Project Area Location	Contributor to Impaired Reach
San Joaquin River (Tuolumne R. to Stanislaus R)			SJ5		
Stanislaus River, Lower			SJ6		
Tuolumne River, Lower (Don Pedro Reservoir to San Joaquin River)			SJ7		
San Joaquin River (Stanislaus R. to Delta Boundary)			SJ8		
Orestimba Creek (Below Kilburn Road)			SJ9		
Orestimba Creek (Above Kilburn Road)			SJ10		
Merced River, Lower (McSwain Reservoir to San Joaquin River)			SJ11		
Delta Waterways (Eastern portion)			DWW2		
Delta Waterways (Southern portion)			DWW4		
X: Not yet determined by TMDL Staff					

3.8.2 NPDES Facilities in the Sacramento River Basin

To date, staff have compiled sixty-two NPDES facilities in the Sacramento River Basin project area (Table 19). According to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins (Basin Plan, 2009), the Sacramento River Basin covers 27,210 square miles and includes the entire area drained by the Sacramento River. This includes all watersheds tributary to the Sacramento River that are north of the Cosumnes River watershed. This description is more broad than the OC project area, which is limited to lands below major reservoirs such as Shasta dam and Oroville dam.

The Sacramento River watershed description in the Basin Plan does not specify various major and minor subareas (as is the case in the SJR Basin). Since the impaired portions for the proposed BPA in the Sacramento River Basin include the Colusa Basin Drain and the lower Feather River (Lake Oroville Dam to confluence with the Sacramento River), for NPDES facilities in the watersheds of these two impaired reaches, For NPDES facilities outside of the watersheds of these two impaired reaches, Staff only classified them being in the Sacramento River Basin (Table 19).

19. Preliminary List of NPDES Facilities in the Sacramento River Basin Project Area					
NPDES #	**Facility**	**Facility Type**	**County**	**Project Area Location**	**Contributor to Impaired Reach**
Municipal Wastewater Treatment Plants					
CA0077852	Rio Alto Water District Lake California WWTP	Municipal WWTP	Tehama	Sacramento R. Basin	DWW5, DWW8
CA0077704	Anderson WWTP	Municipal WWTP	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0077712	Auburn WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5, DWW8
CA0078930	Biggs WWTP	Municipal WWTP	Butte	Sacramento R. Basin	DWW5, DWW8
CA0079081	Chico Regional WWTP	Municipal WWTP	Butte	Sacramento R. Basin	DWW5, DWW8
CA0078999	Colusa WWTP	Municipal WWTP	Colusa	Colusa Basin Drain	SAC2, DWW5, DWW8
CA0004995	Corning Industrial and Domestic WWTP	Municipal WWTP	Tehama	Sacramento R. Basin	DWW5, DWW8
CA0081507	Cottonwood WWTP	Municipal WWTP	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0084476	Lincoln WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5, DWW8
CA0079022	Live Oak WWTP	Municipal WWTP	Sutter	Sacramento R. Basin	DWW5, DWW8
CA0079987	Maxwell PUD WWTP	Municipal WWTP	Colusa	Colusa Basin Drain	SAC2, DWW5, DWW8
CA0077836	Olivehurst PUD WWTP	Municipal WWTP	Yuba	Feather River	SAC1, DWW5, DWW8
CA0079235	Oroville WWTP	Municipal WWTP	Butte	Feather River	SAC1, DWW5, DWW8
CA0079341	Placer County Service Area #28 Zone #6	Municipal WWTP	Placer	Feather River	SAC1, DWW5, DWW8
CA0079316	Placer County Sewer Maintenance District #1 WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5
CA0079367	Placer County Sewer Maintenance District #3 WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5
CA0078891	Red Bluff WWRP	Municipal WWTP	Tehama	Sacramento R. Basin	DWW5, DWW8
CA0079731	Redding Clear Creek WWTP	Municipal WWTP	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0082589	Redding Stillwater WWTP	Municipal WWTP	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0079502	Roseville Dry Creek WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5
CA0084573	Roseville Pleasant Grove WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5
CA0079511	Shasta Lake WWTP	Municipal WWTP	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0084697	United Auburn Indian Community Casino WWTP	Municipal WWTP	Placer	Sacramento R. Basin	DWW5
CA0077933	Williams WWTP	Municipal WWTP	Colusa	Colusa Basin Drain	SAC2, DWW5, DWW8
CA0079260	Yuba City WWTP	Municipal WWTP	Sutter	Feather River	SAC1, DWW5, DWW8
CA0077691	Vacaville Easterly	Municipal WWTP	Solano	Alamo Creek Watershed	DWW8

19. Preliminary List of NPDES Facilities in the Sacramento River Basin Project Area					
NPDES #	**Facility**	**Facility Type**	**County**	**Project Area Location**	**Contributor to Impaired Reach**
	WWTP				
CA0077950	Woodland WWTP	Municipal WWTP	Yolo	Sacramento R. Basin	DWW5, DWW8
CA0079049	Davis WWTP	Municipal WWTP	Yolo	Sacramento R. Basin	DWW8
CA0077895	UC Davis WWTP	Municipal WWTP	Yolo	Sacramento R. Basin	DWW8
Minor Point Sources					
CA0082767	Crystal Creek Aggregate	Aggregate	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0083097	J.F. Shea Company Fawndale Rock and Asphalt (Aggregate)	Aggregate	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0081191	Lehigh Southwest Cement Company	Aggregate	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0084140	Stimpel Wiebelhaus Associates at Mountain Gate (Aggregate)	Aggregate	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0004774	Department of Fish and Game Nimbus Fish Hatchery	Aquaculture	Sacramento	Sacramento R. Basin	DWW5
CA0004561	Department of Fish and Game, Darrah Springs Fish Hatchery	Aquaculture	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0082961	Pacific Coast Sprout Farms Inc Sacramento Facility (Aquaculture)	Aquaculture	Sacramento	Sacramento R. Basin	DWW5
CA0080799	Bella Vista Water District WTP	Drinking Water Treatment	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0083828	Clear Creek CSD WTP	Drinking Water Treatment	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0004693	Shasta Lake WTP	Drinking Water Treatment	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0083143	South Feather Water and Power (Water Supply)	Drinking Water Treatment	Butte	Sacramento R. Basin	SAC1, DWW5, DWW8
CA0083721	Bell Carter Olive Company Inc (Food Processing)	Food Processing	Tehama	Sacramento R. Basin	DWW5, DWW8
CA0083861	Aerojet Interim Groundwater Extraction and Treatment System	Groundwater Remediation	Sacramento	Sacramento R. Basin	DWW5
CA0084891	Boeing Co. Interim Groundwater Extraction and Treatment System	Groundwater Remediation	Sacramento	Sacramento R. Basin	DWW5
CA0004111	Aerojet Sacramento Facility	Heating / Cooling	Sacramento	Sacramento R. Basin	DWW5
CA0004057	Formica Corporation Sierra plant (Manufacturing)	Manufacturing	Placer	Sacramento R. Basin	DWW5, DWW8
CA0004316	Proctor & Gamble WWTP	Manufacturing	Sacramento	Sacramento R. Basin	DWW5
CA0004821	Pactiv Molded Pulp Mill	Paper/Saw Mill	Tehama	Sacramento R. Basin	DWW5, DWW8
CA0082066	Sierra Pacific Industries Anderson Division (Paper/Saw Mill)	Paper/Saw Mill	Shasta	Sacramento R. Basin	DWW5, DWW8

19. Preliminary List of NPDES Facilities in the Sacramento River Basin Project Area					
NPDES #	**Facility**	**Facility Type**	**County**	**Project Area Location**	**Contributor to Impaired Reach**
CA0081400	Sierra Pacific Industries Shasta Lake (Paper/Saw Mill)	Paper/Saw Mill	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0081566	Calpine Corporation Greenleaf Unit One Cogeneration Plant	Power Generation	Sutter	Sacramento R. Basin	DWW5, DWW8
CA0083569	Sacramento Cogeneration Authority Procter & Gamble Plant	Power Generation	Sacramento	Sacramento R. Basin	DWW5
CA0081957	Wheelabrator Shasta Energy Company (Power Generation)	Power Generation	Shasta	Sacramento R. Basin	DWW5, DWW8
CA0078581	CA State of Central Heating/Cooling Facility	Heating / Cooling	Sacramento	Sacramento R. Basin	DWW5, DWW8
CA0078875	DGS Office of State Publishing	Miscellaneous	Sacramento	Sacramento R. Basin	DWW5
CA0034841	Sacramento International Airport	Heating / Cooling	Sacramento	Sacramento R. Basin	DWW5, DWW8
CA0083348	UC Davis Center for Aquatic Biology & Aquaculture Aquatic Center	Aquaculture	Yolo/Solano	Sacramento R. Basin	DWW8
CA0083348	UC Davis Center for Aquatic Biology & Aquaculture Putah Ck Facility	Aquaculture	Yolo/Solano	Sacramento R. Basin	DWW8
CA0084182	UC Davis Hydraulics Laboratory	Miscellaneous	Yolo	Sacramento R. Basin	DWW8
Stormwater Permittees					
CA0082597	County of Sacramento and the Cities of Sacramento, Citrus Heights, Elk Grove, Folsom, Galt, Rancho Cordova	Municipal Separate Stormwater Sewer System (MS4)	Sacramento	Sacramento R. Basin	DWW5, DWW8
CA0083500*	Central Valley Regional Board, Caltrans District 6	CALTRANS General Stormwater Permit	Several	Sacramento R. Basin	DWW5, DWW8
*CA0083640	Central Valley Regional Board, Caltrans Districts 3, 4, 6 and 10	CALTRANS General Stormwater Permit	Several	Sacramento R. Basin	DWW5, DWW8
**CAS000004	Applicable Phase IIs in Project Area (List available upon request)	Small MS4s (Phase IIs)	Several	Sacramento R. Basin	DWW5, DWW8

Contributor to Impaired Reach Codes	
Feather River, Lower (Oroville Dam to confluence with Sacramento River)	SAC1
Colusa Basin Drain	SAC2
Delta Waterways (Northern portion)	DWW5
Delta Waterways (Northwestern portion)	DWW8
*State Water Board, 1999	
** State Water Board, 2003	

3.5.3 NPDES Facilities in the Sacramento-San Joaquin Delta

To date, staff have complied twenty-two NPDES facilities in the 8 impaired portions within the Legal Delta (Table 20). As noted previously in Module 1, the cumulative Project Area for the 8 Delta waterways Portions includes a very large geographic area. In addition to the NPDES facilities in the vicinity of the impaired waterbodies for this project, as shown in Tables 18 and 19, there are numerous other NPDES facilities that are outside the 8 impaired portions and are in the project area located within the San Joaquin River Basin and the Sacramento River Basins.

Table 20. Preliminary List of NPDES Facilities in the Sacramento-San Joaquin Delta Project Area

NPDES #	Facility	Facility Type	County	Project Area Location	Contributor to Impaired Reach
Municipal Wastewater Treatment Plants					
CA0082660	Brentwood WWTP	Municipal WWTP	Contra Costa	Delta Waterways, Western Portion	DWW3
CA0078093	Deuel Vocational Institute WWTP	Municipal WWTP	San Joaquin	Delta Waterways, Southern Portion	DWW3, DWW4, DWW6
CA0078590	Discovery Bay WWTP	Municipal WWTP	Contra Costa	Delta Waterways, Central Portion	DWW6
CA0079243	Lodi White Slough WWTP	Municipal WWTP	San Joaquin	Delta Waterways, Eastern Portion	DWW2
CA0082783	Manteca WWTP	Municipal WWTP	San Joaquin	Delta Waterways, Eastern Portion	DWW2
CA0079588	Rio Vista Main WWTP	Municipal WWTP	Solano	Delta Waterways, Northern Portion	DWW2, DWW5, DWW6
CA0082848	San Joaquin Co DPW Flag City	Municipal WWTP	San Joaquin	Delta Waterways, Eastern Portion	DWW2
CA0077682	SRCSD Sacramento River WWTP	Municipal WWTP	Sacramento	Delta Waterways, Northern Portion	DWW2, DWW5, DWW6
CA0078794	SRCSD Walnut Grove WWTP (CSD1)	Municipal WWTP	Sacramento	Delta Waterways, Central Portion	DWW6
CA0079138	Stockton WWTP	Municipal WWTP	San Joaquin	Delta Waterways, Eastern Portion	DWW2
CA0079154	Tracy WWTP	Municipal WWTP	San Joaquin	Delta Waterways, Southern Portion	DWW3, DWW4, DWW6
CA0079171	West Sacramento WWTP	Municipal WWTP	Yolo	Delta Waterways, Northern Portion	DWW2, DWW5, DWW6
Minor Point Sources					
CA0081931	Defense Logistics Agency Sharpe Army Deport	Groundwater Remediation	San Joaquin	Delta Waterways, Southern Portion	DWW3, DWW4, DWW6
CA0081965	Stockton Cogeneration Facility	Power Generation	San Joaquin	Delta Waterways, Southern Portion	DWW3, DWW4, DWW6
CA0083968	CALAMCO - Stockton Terminal	Heating / Cooling	San Joaquin	Delta Waterways, Eastern Portion	DWW2
CA0004847	Gaylord Container Corp. Antioch Pulp & Paper	Heating / Cooling	Contra Costa	Delta Waterways, Western Portion	DWW3
CA0082309	GWF Power Systems	Power Generation	Contra Costa	Delta Waterways, Western Portion	DWW3
CA0082783	Manteca Aggregate Sand Plant (Oakwood Lake S)	Aggregate	San Joaquin	Delta Waterways, Eastern Portion	DWW2
CA0004863	Mirant Delta CCPP	Power Generation	Contra Costa	Delta Waterways, Western Portion	DWW3
Stormwater Permittees					
CA0083313	City of Antioch, City of Brentwood, City of Oakley, Contra Costa County, Contra Costa County Flood Control and Water Conservation District	Municipal Separate Stormwater Sewer System (MS4)	Contra Costa	Delta Waterways, Western Portion; (City of Antioch lies outside legal Delta boundary)	DWW3,DWW6
CAS083470	City of Stockton and County of San Joaquin	Municipal Separate Stormwater Sewer	San Joaquin	Delta Waterways, Eastern Portion	DWW2

Table 20. Preliminary List of NPDES Facilities in the Sacramento-San Joaquin Delta Project Area					
NPDES #	**Facility**	**Facility Type**	**County**	**Project Area Location**	**Contributor to Impaired Reach**
		System (MS4)			
CAS0084077	Stockton Port District Facility Wide Stormwater MS4 and non-stormwater discharges from the Port of Stockton	Municipal Separate Stormwater Sewer System (MS4)	San Joaquin	Delta Waterways, Eastern Portion	DWW2

Contributor to Impaired Reach Codes

Delta Waterways (Stockton Ship Channel)	DWW1
Delta Waterways (Eastern portion)	DWW2
Delta Waterways (Western portion)	DWW3
Delta Waterways (Southern portion)	DWW4
Delta Waterways (Northern portion)	DWW5
Delta Waterways (Central portion)	DWW6
Delta Waterways (Export area)	DWW7
Delta Waterways (Northwestern portion)	DWW8

3.9 Estimation of OC Loads in Water by Source

Concentrations of OCs in water are the result of loads from point source and non-point source discharges. The analysis in this section considers OC loads into the watersheds of the 21 waterbody reaches, using both DDE and Lindane as representative constituents.

The information presented here is in support of Module 2 which focuses on preliminary information regarding source analysis, while Module 3 will discuss allocations. In order to estimate existing current conditions, staff conducted an analysis based on flow and concentrations for OC pesticide load assessment in the Project Area. Pollutant loading, and allocations determined based on loading, that a waterbody can safely assimilate can be expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). For OCs, staff's initial indications are that it may be difficult to implement a mass-per-time allocation, given that the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, very high loads of OC constituents are allowable if the volume of water that transports OC constituents is also high. Conversely, a relatively low load of OC constituents may exceed water quality standards if flow rates are low. In watersheds such as those in the Central Valley where downstream entities have various impaired reaches draining to their subwatershed, if each of those reaches has its own mass-per-time load levels, compliance with each of the assigned load allocations for reaches is likely to be bring confusion. In addition, the water quality standard is also expressed in terms of the constituent concentration per liter or constituent concentration per kilogram. Therefore, based on the aforementioned reasons, staff's initial approach will be to express the OC allocations as concentration-based. The above information is a side note in regards to source analysis, and the topic of allocations will be addressed in Module 3.

In order to assess current conditions, Staff opted to express existent loads in the watershed based on available flow data from WARMF and concentration data from monitoring stations. WARMF is a Watershed Analysis Risk Management Framework model that facilitates TMDL analysis and watershed planning and was developed as a decision support system. The system can provide a road map to calculate TMDLs for most conventional pollutants (coliform, TSS, BOD, nutrients). WARMF also can be used to help stakeholders explore implementation scenarios. The scientific basis of the model and the consensus process has undergone several peer reviews by independent experts under EPA guidelines. WARMF is organized into five (5) linked modules under one, GIS-based graphical user interface (GUI). The 5 modules are: engineering, data, knowledge, TMDL and consensus. The WARMF model is available for public download at: http://www.epa.gov/athens/wwqtsc/html/warmf.html

For this supplemental information, the WARMF model was not used to run any scenarios but was used as a source for flow data and land use estimates for the various catchments in the watershed. Average annual OC loads were estimated based on flow data from the WARMF data module. In addition, USGS and DWR monitoring gages provided data for daily flows for the major tributaries to the San Joaquin River, Sacramento River and the Sacramento-San Joaquin Delta (CEDC, 2010).

The loads are characterized are based on available water quality and flow data for the reaches in the project area. Load (mass per time, L) is calculated as the product of concentration and flow rate based on Equation 10:

Equation (10):

$$L = C * Q.$$

Where*:* L = Load (mass per time)
C = product of concentration
Q = flow rate

Flow rates for each land use in each watershed were derived from daily mean values for water years 1984-2007 data that is populated in WARMF with data from the USGS and California Data Exchange Center. DDE and Lindane concentrations from major sources to water are based on data from land-use runoff and discharge data presented in the Current Conditions Section (Section 2). The underlying assumption in this assessment is that the concentration of pollutant received at the base of each subwatershed is representative of its prevailing land uses. As a result, with the exception of POTWs, other land uses in a given subwatershed were assigned the pollutant concentration in the discharge data with the only variable being flow rates. Loads were calculated for DDE and Lindane sources from land-use runoff data and point source discharges to receiving water was quantified from data received from Self Monitoring Reports (SMRs). The sum of these loads presumably represents the total load of OCs to waterbodies. Staff notes that from the 104 NPDES discharges (Tables 18, 19 and 20) in the watershed, SMR data was analyzed for 26 facilities (9 selected to represent the San Joaquin River watershed, 9 from the Sacramento River watershed and 9 from the Sacramento-San Joaquin Delta).

Based on land use analysis, average constituent concentrations from water column data and the associated flow rates for each land use category within a given reach (See Section 3.1), the percentage loads for each reach were computed as shown in Table 21, using DDE and Lindane as representative OC constituents. Staff then calculated load as flow rate multiplied by concentration and converted to the appropriate units (Table 21). Conversion factors are not shown in Table 21. Average DDE and Lindane concentrations and estimated annual average loads of these constituents from major land use categories are shown in Figure 10 and Table 21. Non-point source runoff includes runoff from the following groups: native (5.89 lb/yr), agriculture (217.01 lb/yr), rangeland/grassland (172.57 lb/yr), open water (24 lb/yr) and forests (3 lb/yr), POTWs (1.2 lb/yr). Some of the loads from the urban category could be considered under non-point source loads and as such, urban areas not encompassed by a MS4 service area will be grouped into the NPS category. Table 21 can also be useful in estimating the overall load contributions from the various reaches within the Project Area.

Assessing sources of legacy pesticides in Central Valley waterbodies is a challenging task. With the exception of PUR data, detailed records of past uses for these chemicals are either scarce or non-existent. Land use mapping and GIS resources offer fewer and less detailed impressions of past conditions than present ones. Issues related to long term fate and transport of OC constituents create additional uncertainties. Despite these known challenges, a significant foundation of understanding has been established by reviewing literature, analyzing available data (such as PURs, land use layers, crop reports and watershed monitoring data). Cumulative understanding of OC constituents sources resulting from all the above mentioned efforts guides the process of linkage analysis and determination of allocations.

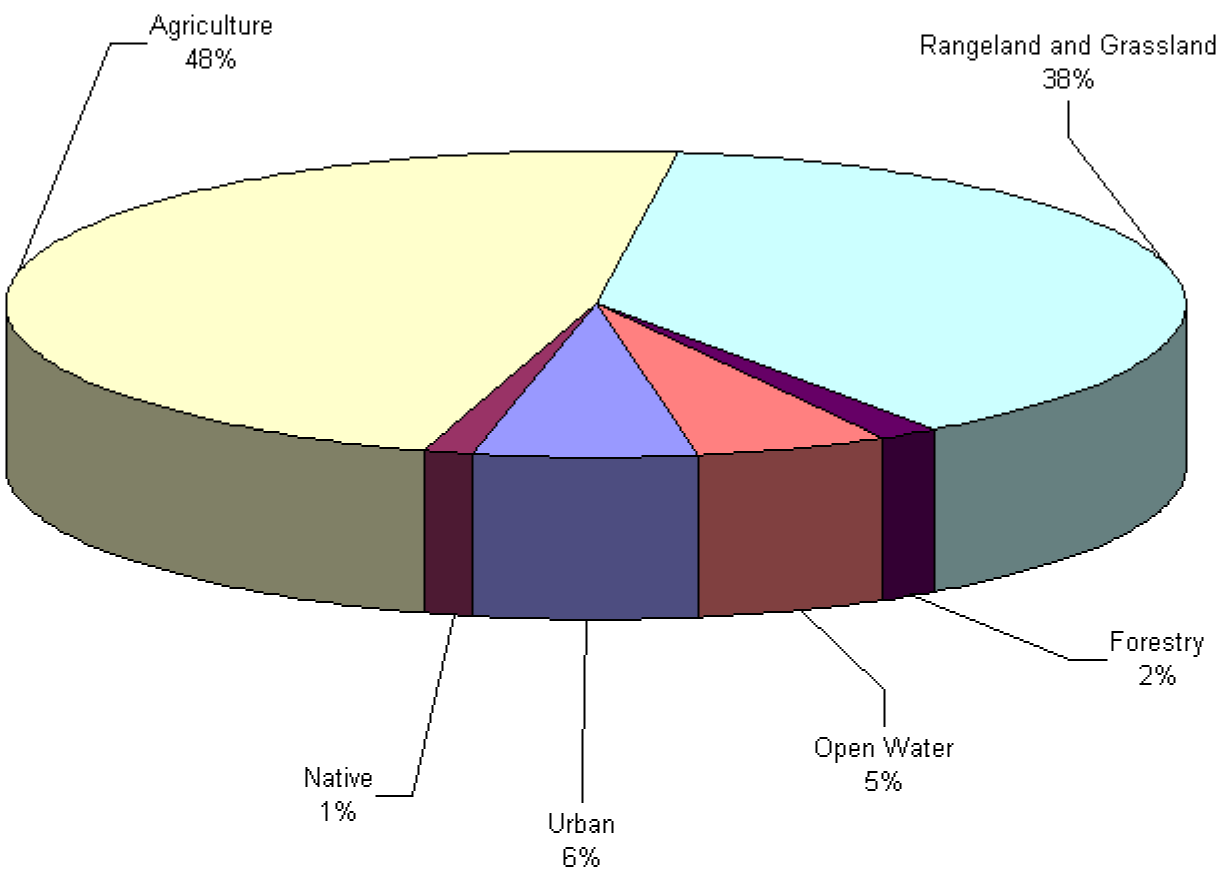

Figure. 10. Percentage load by land use category in the TMDL Project Area

Table 21. Estimated average annual load of DDE and Lindane from major land use categories

Load is calculated as flow rate multiplied by concentration and converted to appropriate Units

		Land use Type						Total
	OC	Urban	Native	Agriculture	Rangeland and Grassland	Forestry	Open water	
Subwatershed		Flow (cfs)						Average Flow (cfs)
San Joaquin River (Mendota Pool to Bear Creek)		6.43	14.25	270.15	209.92	8.19	3.20	420.00
San Joaquin River (Bear Creek to Mud Slough)		5.01	89.26	314.58	413.84	0.00	5.34	828.00
San Joaquin River (Mud Slough to Merced River)		1.34	8.02	49.88	49.98	0.29	1.61	100.00
San Joaquin River (Merced River to Tuolumne River)		93.03	94.15	2725.70	1796.33	21.67	4.93	3594.00
Tuolumne River, Lower		84.96	2.58	440.53	601.77	221.68	4.82	1204.00
Merced River, Lower		4.35	25.80	303.79	260.90	25.67	0.72	522.00
Orestimba Creek (Above Kilburn Road)		0.20	0.16	9.26	8.95	0.60	0.00	17.90
Orestimba Creek (Below Kilburn Road)		0.49	0.40	23.17	22.39	1.50	0.00	44.80
Stanislaus River Lower		42.27	37.21	480.17	149.38	69.88	3.08	782.00
San Joaquin River (Tuolumne R. to Stanislaus R.)		237.00	126.23	2393.97	2150.50	920.33	11.92	5840.00
San Joaquin River (Stanislaus to Delta Boundary)		195.87	65.44	2806.47	2057.23	463.34	17.46	4116.00
Colusa Basin Drain		41.80	9.11	626.16	417.84	0.00	0.08	836.00
Feather River		393.12	227.14	2306.30	2183.18	43.68	87.36	4368.00
Delta Waterways		200.61	29.42	1389.21	1124.08	0.00	202.41	2249.00
		Concentration (ug/L)						
San Joaquin River (Mendota Pool to Bear Creek)	DDE	0.004	0.004	0.004	0.004	0.004	0.004	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
San Joaquin River (Bear Creek to Mud Slough)	DDE	0.004	0.004	0.004	0.004	0.004	0.004	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
San Joaquin River (Mud Slough to Merced River)	DDE	0.004	0.004	0.004	0.004	0.004	0.004	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
San Joaquin River (Merced River to Tuolumne River)	DDE	0.009	0.009	0.009	0.009	0.009	0.009	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
Tuolumne River, Lower	DDE	0.005	0.005	0.005	0.005	0.005	0.005	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
Merced River, Lower	DDE	0.004	0.004	0.004	0.004	0.004	0.004	
	Lindane	0.005	0.005	0.005	0.005	0.005	0.005	
Orestimba Creek (Above Kilburn Road)	DDE	0.007	0.007	0.007	0.007	0.007	0.007	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
Orestimba Creek (Below Kilburn Road)	DDE	0.008	0.008	0.008	0.008	0.008	0.008	
	Lindane	0.005	0.005	0.005	0.005	0.005	0.005	
Stanislaus River Lower	DDE	0.004	0.004	0.004	0.004	0.004	0.004	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
San Joaquin River (Tuolumne R. to	DDE	0.004	0.004	0.004	0.004	0.004	0.004	

Table 21. Estimated average annual load of DDE and Lindane from major land use categories

Stanislaus R.)	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
San Joaquin River (Stanislaus to Delta Boundary)	DDE	0.011	0.011	0.011	0.011	0.011	0.011	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
Colusa Basin Drain	DDE	0.005	0.005	0.005	0.005	0.005	0.005	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
Feather River	DDE	0.005	0.005	0.005	0.005	0.005	0.005	
	Lindane	0.004	0.004	0.004	0.004	0.004	0.004	
Delta Waterways	DDE	0.282	0.282	0.282	0.282	0.282	0.282	
	Lindane	0.004	0.004	0.004		0.004	0.004	
		Average Annual Loads (lb/yr)						**Total**
San Joaquin River (Mendota Pool to Bear Creek)	DDE	0.01	0.02	0.44	0.34	0.01	0.01	0.83
	Lindane	0.01	0.02	0.44	0.34	0.01	0.01	0.83
San Joaquin River (Bear Creek to Mud Slough)	DDE	0.00	0.01	0.51	0.67	0.00	0.01	1.21
	Lindane	0.00	0.01	0.51	0.67	0.00	0.01	1.20
San Joaquin River (Mud Slough to Merced River)	DDE	0.00	0.01	0.08	0.08	0.36	0.00	0.54
	Lindane	0.00	0.01	0.08	0.08	0.36	0.00	0.54
San Joaquin River (Merced River to Tuolumne River)	DDE	0.34	0.34	9.94	6.55	0.08	0.02	17.27
	Lindane	0.15	0.15	4.42	2.91	0.04	0.01	7.68
Tuolumne River, Lower	DDE	0.17	0.01	0.89	1.22	0.45	0.01	2.75
	Lindane	0.14	0.00	0.71	0.98	0.36	0.01	2.20
Merced River, Lower	DDE	0.01	0.04	0.49	0.42	0.04	0.00	1.01
	Lindane	0.01	0.05	0.62	0.53	0.05	0.00	1.26
Orestimba Creek (Above Kilburn Road)	DDE	0.00	0.00	0.03	0.03	0.00	0.00	0.05
	Lindane	0.00	0.00	0.02	0.01	0.00	0.00	0.03
Orestimba Creek (Below Kilburn Road)	DDE	0.00	0.00	0.08	0.07	0.00	0.00	0.16
	Lindane	0.00	0.00	0.05	0.05	0.00	0.00	0.10
Stanislaus River Lower	DDE	0.07	0.06	0.83	0.26	0.12	0.01	1.35
	Lindane	0.07	0.06	0.78	0.24	0.11	0.00	1.27
San Joaquin River (Tuolumne R. to Stanislaus R.)	DDE	0.38	0.20	3.88	3.49	1.49	0.02	9.47
	Lindane	0.38	0.20	3.88	3.49	1.49	0.02	9.47
San Joaquin River (Stanislaus to Delta Boundary)	DDE	0.84	0.28	12.04	8.83	1.99	0.07	24.06
	Lindane	0.32	0.11	4.61	3.38	0.76	0.03	9.20
Colusa Basin Drain	DDE	0.08	0.02	1.27	0.85	0.00	0.00	2.22
	Lindane	0.07	0.01	1.01	0.68	0.00	0.00	1.77
Feather River	DDE	0.80	0.46	4.67	4.42	0.09	0.18	10.62
	Lindane	0.64	0.37	3.74	3.54	0.07	0.14	8.50
Delta Waterways	DDE	22.93	3.36	158.75	128.46	0.00	23.13	336.63
	Lindane	0.33	0.05	2.25	0.00	0.00	0.33	2.95
Total Load by Land Use Type		**27.76**	**5.89**	**217.01**	**172.57**	**7.90**	**24.01**	**455.14**
Percent of Total by Load		**6.10**	**1.29**	**47.68**	**37.92**	**1.74**	**5.28**	**100.00**

*Flow values from Delta Waterways were coarse estimates due to inconsistency in data sets regarding how tidal flows were measured.

7.0. References

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